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WATER SUPPLY AND WATER QUALITY CONTROL STUDY TIOGA-HAMMOND-COWANESQUE RESERVOIRS, CHEMUNG RIVER BASIN, PENNSYLVANIA AND NEW YORK

Federal Water Pollution Control
Administration
Charlottesville, Virginia

May 1969

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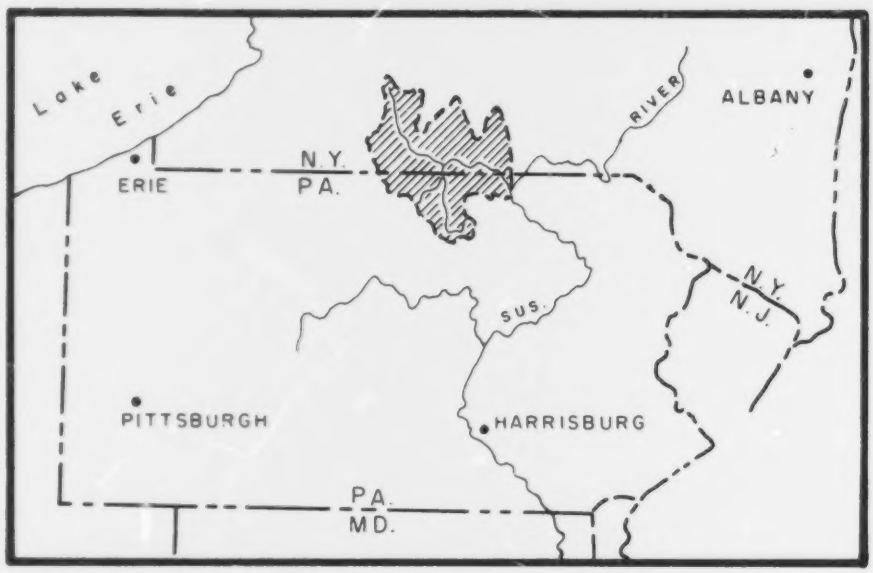
WATER SUPPLY AND WATER QUALITY CONTROL STUDY CHEMUNG RIVER BASIN PA. - N.Y.

(Tioga - Hammond - Cowanesque Reservoir)



STUDY OF NEEDS AND VALUE OF STORAGE FOR WATER SUPPLY AND WATER QUALITY CONTROL

U.S. DEPT. OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
MIDDLE ATLANTIC REGION
CHARLOTTESVILLE VIRGINIA
MAY 1969

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WATER SUPPLY AND WATER QUALITY CONTROL STUDY
TIOGA-HAMMOND-COWANESQUE RESERVOIRS

Chemung River Basin

Pennsylvania and New York

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An investigation has been made which discloses that storage for streamflow regulation in the Tioga-Hammond-Cowanesque Reservoirs can contribute to municipal and industrial water supply and water quality control purposes in the Chemung River Basin. These conclusions are based on demographic, economic, and engineering studies. Future conditions are based on projected population and industrial growth.

Prepared at the request of the U. S. Department of the Army, Baltimore District, Corps of Engineers, Baltimore, Maryland

U. S. Department of the Interior
Federal Water Pollution Control Administration
Middle Atlantic Region
Charlottesville, Virginia

May 1969

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I. INTRODUCTION

REQUEST AND AUTHORITY

In a letter dated October 1, 1965, the Baltimore District of the Corps of Engineers requested a study of the Tioga-Hammond Reservoir Project near Tioga, Pennsylvania, to evaluate the need for reservoir storage for water supply and water quality control in the Tioga River and Chemung River Basins.

In a letter dated December 20, 1966, the Baltimore District of the Corps of Engineers requested a similar study for the Cowanesque Reservoir Project on the Cowanesque River. Due to the close proximity of the Cowanesque and the Tioga-Hammond Projects, agreement was reached to include evaluations of both Projects in this report.

The water supply portion of this study was made in accordance with the Memorandum of Agreement dated November 4, 1958, between the Department of the Army and the Department of Health, Education, and Welfare relative to the Water Supply Act of 1958, as amended (43 U.S.C. 3906). The water quality control aspects are considered under authority of the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et seq). Responsibility for these activities was transferred from the Department of Health, Education, and Welfare to the Department of the Interior by Reorganization Plan No. 2 of 1966, effective May 10, 1966.

PURPOSE AND SCOPE

The purposes of this study are to determine the need for and value of reservoir storage for municipal and industrial water supply and the contribution that flow regulation by the Tioga-Hammond-Cowanesque Reservoirs could make to water quality control in the Tioga River and Chemung River Basins. The objectives of the study included: (1) identification of present municipal and industrial water uses and waste loads; (2) estimation of future water requirements and waste loads based on economic projections; (3) determination of waste treatment and streamflow required to meet established water quality objectives; and (4) determination of costs which can be used to derive the value of reservoir storage for water supply and for water quality control.

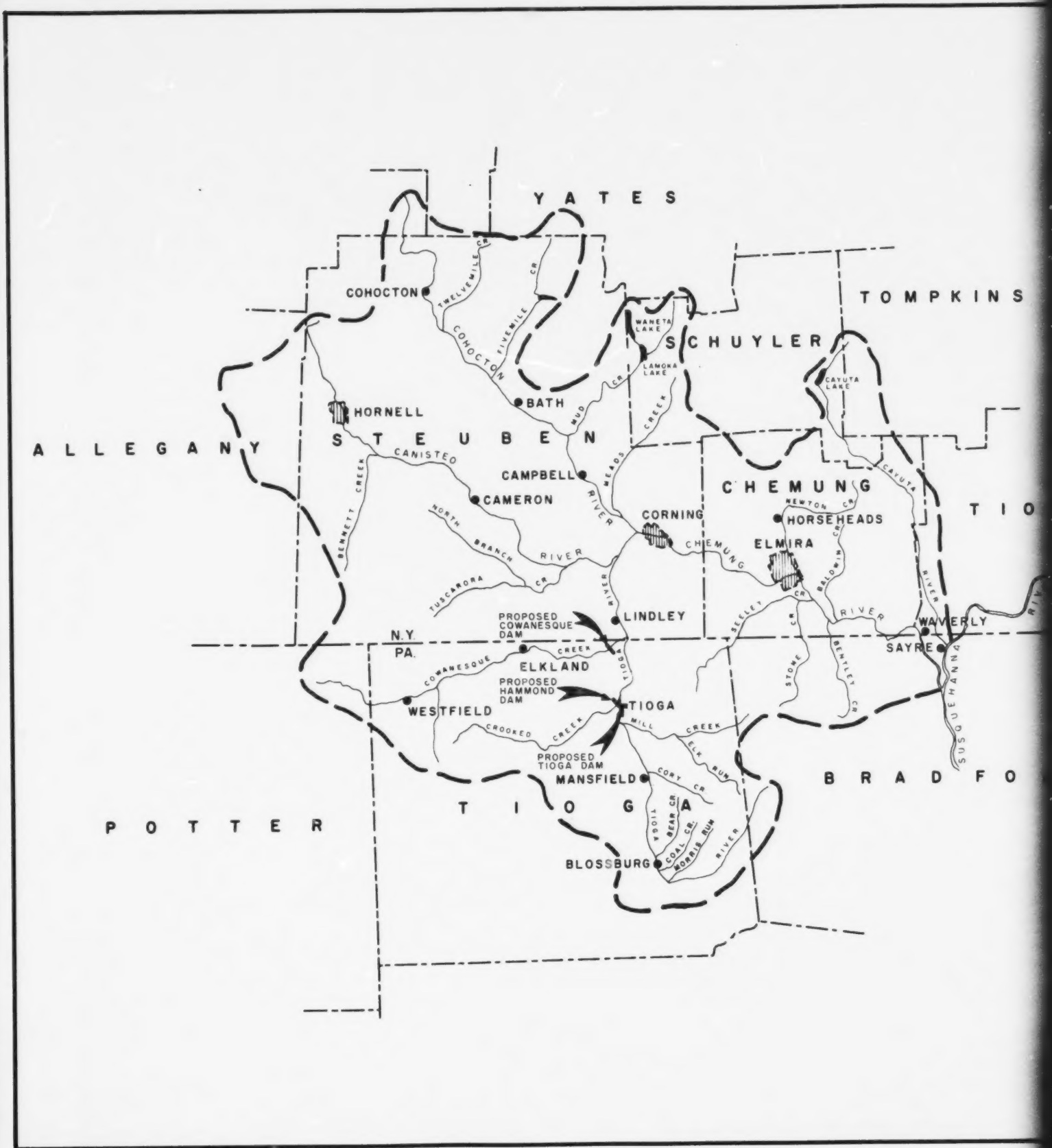
The study area is comprised of the entire Tioga-Chemung River Basin, including the Cowanesque, Canisteo, and Cohocton River Watersheds. Geographically, this area includes portions of three counties in Pennsylvania and portions of seven counties in New York.

The design period of the study on water supply and water quality control needs is 50 years, from 1970 to 2020. The base year is taken as 1970.

ACKNOWLEDGMENTS

The cooperation and assistance of the following Federal, State, and local agencies are gratefully acknowledged:

U. S. Army Engineer District, Baltimore Maryland
U. S. Geological Survey, Harrisburg, Pennsylvania
U. S. Geological Survey, Ithaca, New York
U. S. Department of Commerce
U. S. Weather Bureau, Asheville, North Carolina
Pennsylvania Department of Health, Harrisburg, Pennsylvania
New York Department of Health, Albany, New York
New York Conservation Department
Local Municipal Officials
Local Industrial Officials


YATES
COHOCTON
TWELVEMILE CR
FIVEMILE CR
COHOCTON
WANETA LAKE
LAMOKA LAKE
CAYUTA LAKE
TOMPKINS
SCHUYLER
HORNELL
BATH
MUD CR
MEADS CREEK
ALLEGANY
STEUBEN
CANISTEO
BENNETT CREEK
CAMPBELL
CAMERON
RIVER
CHEMUNG
CAYUTA
NEWTON CR
CORNING
HORSEHEADS
NORTH BRANCH
RIVER
CHEMUNG
ELMIRA
BALDWIN CR
TUSCARORA CR
RIVER
RIVER
PROPOSED COWANESQUE DAM
LINDLEY
SEELEY CR
RIVER
WAVERLY
N.Y.
PA.
COWANESQUE CREEK
ELKLAND
SAYRE
PROPOSED HAMMOND DAM
TIOGA
STONE CR
BENTLEY CR
SUSQUEHANNA
WESTFIELD
CROOKED CREEK
MILL CREEK
ELK RUN
PROPOSED TIOGA DAM
MANSFIELD
CORY CR
BRADFO
TIOGA
POTTER
BEAR CR
COAL CR
MORRIS RUN
RIVER
BLOSSBURG

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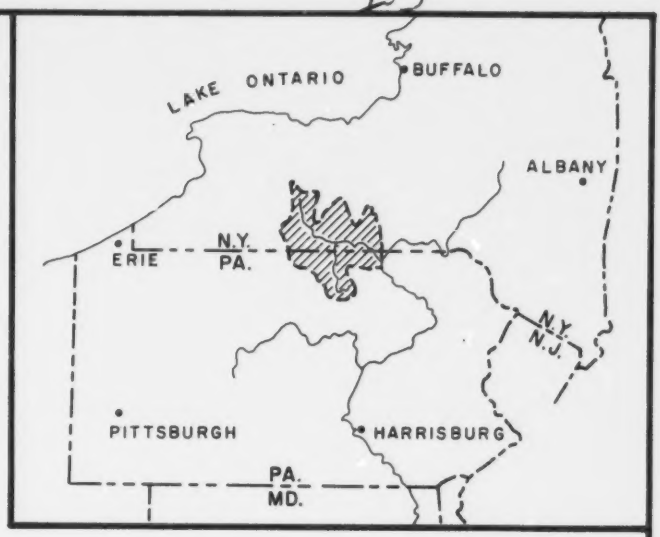

LOCATION MAP

SCALE IN MILES

10 0 10 20 30 40

WATER SUPPLY & WATER QUALITY CONTROL STUDY
SUSQUEHANNA RIVER BASIN

CHEMUNG RIVER SUB BASIN

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
MIDDLE ATLANTIC REGION CHARLOTTESVILLE, VA.

B

FIG. 1

II. SUMMARY OF FINDINGS AND CONCLUSIONS

FINDINGS

1. The Baltimore District, U. S. Army Corps of Engineers, is considering construction of two multi-purpose reservoirs in the upper portion of the Tioga-Chemung River Basin. The site of the proposed Tioga-Hammond Reservoir Project is located in Pennsylvania at the confluence of Tioga River and Crooked Creek, approximately seven miles south of the Pennsylvania-New York State Line. The proposed Cowanesque Reservoir Project site is located in Pennsylvania on the Cowanesque River, approximately three miles upstream from the point where the Cowanesque joins the Tioga River.

2. The study encompasses all of the Tioga River and Chemung River Basins, having a drainage area of about 2,530 square miles, 690 square miles of which are in Pennsylvania. Included are portions of Bradford, Potter, and Tioga Counties in Pennsylvania, and parts of Allegheny, Chemung, Livingston, Ontario, Schuyler, Steuben, and Yates Counties in New York.

3. Principal communities within the study area are the Cities of Corning, Elmira, and Hornell and the Village of Bath in New York, and the Boroughs of Elkland, Mansfield, and Westfield in Pennsylvania. The 1960 population of these seven communities was approximately 200,000 persons, about half of whom were located in the City of Elmira. The Cities of Corning and Bath are the next two larger communities, with populations of 36,172 and 20,972, respectively.

4. The major industries in the study area are the Corning Glass Works at Corning and the Great Atlantic and Pacific Tea Company, Ann Page Division, at Elmira. Smaller industries, including metal fabrication plants and dairy processing plants, are centered around Elmira and Corning. Lumbering, dairying, and general farming type activities are scattered throughout the study area. In addition, the New York State Electric and Gas Corporation has a steam electric generating station at East Corning, New York.

5. The 1965 municipal and industrial water use in the study area was estimated at 84.1 mgd, of which 43.2 mgd was used for cooling by the New York State Electric and Gas Corporation.

6. Estimates of treated and untreated municipal and industrial wastes in 1965 indicate about 26,000 pounds per day of ultimate BOD were contributed to the waters of the study area.

7. Localized pollution presently occurs downstream from most of the larger communities, particularly during periods of low flow.

8. The Cowanesque River is intermittently degraded downstream from the Boroughs of Westfield and Elkland, Pennsylvania, which discharge primary and secondary treatment wastes, respectively. In addition, wastes from a tannery at Westfield are discharged following the equivalent of primary treatment and from a tannery at Elkland after receiving the equivalent of intermediate treatment. The tannery at Elkland discharges sludge from the primary settling units to drying beds located on the Cowanesque flood plain. These beds are subject to inundation and scour during extreme flood flows.

9. Untreated municipal and industrial wastes result in the degradation of the Canisteo River downstream from Hornell, New York. During periods of low flow, extremely low to zero dissolved oxygen levels have been reported for a distance of ten miles.

10. Localized degradation of the Chemung River occurs downstream from the Village of Painted Post, with more severe degradation occurring downstream from the waste outfalls of the Cities of Corning and Elmira.

11. Mine drainage is by far the most widespread pollution problem in the Chemung River Basin. The Tioga River, flowing northward through Tioga County, receives mine drainage principally from three small tributaries, Morris Run, Coal Run, and Bear Run. The net effect in the Tioga River is the virtual destruction of all biological and aquatic life in the River for a distance of about 38 miles.

12. The Tioga and Chemung Rivers are interstate streams with established water quality standards. The primary uses to be preserved by maintaining water quality in these waters are recreation, sports fishing, and municipal and industrial water supply.

CONCLUSIONS

1. The population of the study area is expected to increase to 711,500 by the year 2020, with the major growth occurring around Corning and Elmira, New York.

2. Municipal water use in the study area is estimated to increase from 19.5 mgd at present to 134 mgd by year 2020. Of this projected quantity, Elmira is expected to need about 90 mgd.

3. Industrial water use in the study area is expected to increase from the current 64.6 mgd to 110 mgd by year 2020. Industry in the Elmira area is projected to use about 75 percent of this quantity.

4. Investigations of the study area indicate that existing natural streamflows, presently developed groundwater supplies, and further development of groundwater resources could adequately meet the projected municipal and industrial needs of Mansfield, Westfield, Elkland, Hornell, Bath, and Corning.

5. By the year 1980, Elmira is expected to experience water shortages unless provisions are made for further development of groundwater resources or reservoir storage. Preliminary estimates of subsurface conditions in the vicinity of Elmira indicate that with artificial recharge, groundwater reserves might be developed to meet the needs through year 2020. However, the uncertainties of feasibly developing a large well system to continuously supply needs of 172 mgd has precluded its consideration in this report as a favorable alternative to surface water development. Additional investigation of the groundwater development alternative is necessary.

6. If surface water is used to meet Elmira's increasing water supply needs, including industrial cooling water, reservoir storage of approximately 37,000 acre-feet would be required through year 2020. Excluding industrial cooling water, approximately 29,500 acre-feet would be required.

7. Since sufficient data were not available to accurately assess the expansion benefits foregone in the absence of an adequate water supply system, the water supply benefits for the purposes of this report were considered to be equal to the least costly alternative. Storage in a single-purpose reservoir to meet the projected needs at Elmira would, therefore, yield minimum average annual benefits of $609,900, with storage for industrial cooling water being provided, or $486,300 excluding cooling water. If it were possible to accurately estimate the intangible benefits of an assured ample supply of water, it is felt that the total benefits to Elmira would be substantially greater than the above figure.

8. It is estimated that the municipal and industrial waste loadings to the Chemung River by year 2020 from Corning and Elmira will amount to about 42,200 pounds of ultimate BOD, following secondary treatment with 85 percent BOD removal. This is more than twice the 1965 loading from these two communities.

9. With the anticipated growth in the Corning and Elmira areas, the residual waste loads after secondary treatment from these communities will exceed the assured stream assimilative capacity of the Chemung River by the year 1980. With secondary treatment

provided at the two communities, flow requirements to maintain criteria established by water quality standards are estimated to range from approximately 176 cfs in 1980 to more than 500 cfs by 2020 during the critical summer and early fall months.

10. Flow regulation from the proposed Tioga-Hammond and Cowanesque Reservoirs could meet the projected water quality management needs either alone or in combination with increased levels of BOD removal resulting from advanced waste treatment. If secondary treatment is provided throughout the study periods, approximately 66,500 acre-feet of reservoir storage would be required. The average annual cost to provide this storage is approximately $1,160,500. If the level of treatment is increased to provide 90 percent removal of BOD reaching the Chemung River, approximately 27,000 acre-feet of storage would be needed. The combined reservoir and advanced waste treatment costs would be approximately $725,700 annually. With waste treatment efficiency of approximately 95 percent BOD removal, the need for reservoir storage would be eliminated. Advanced waste treatment costs in this case are estimated at $727,600 annually.

11. The minimum benefits attributable to flow regulation were assumed to be equal to the least costly alternative, believing the benefits of providing clean water for the intended areas were at least equal to the least cost of obtaining it. Hence, for the purposes of this report, the average annual value of the benefits resulting from flow regulation is estimated at $725,700.

12. Flow regulation should yield greater intangible benefits than advanced waste treatment, since it would permit increased in-stream use of streamflow, minimize water quality degradation by natural pollution in surface runoff and by industrial cooling water discharges, maintain stream levels during otherwise low flow conditions throughout the year, and provide water quality enhancement for the upstream 20-mile reach between Corning and the proposed reservoirs.

13. The primary beneficiaries from flow regulation are the people, both within and outside the Basin, who use the Chemung River for recreation or fishing or who appreciate the value of clean streams. The value of recreational and sport fishery benefits possible with assured flow and quality in the Chemung River downstream from Corning and Elmira has been estimated at about $166,000 annually. Additional benefits are attributable to water quality improvements as a result of aesthetic enjoyment and the maintenance of property values in the vicinity of the stream. These and other intangible benefits cannot be adequately measured at this time.

14. The benefits are widespread in scope, occurring over 45 miles of stream and appear sufficient in magnitude to warrant provision of the required volume of storage for flow regulation.

15. If adequate storage cannot be provided in the proposed Tioga-Hammond-Cowanesque Reservoirs to meet the water supply and water quality control needs, other potential reservoirs such as in the Canisteo or Cohocton watershed should be considered.

16. The use of storage to blend stored alkaline and acid waters in the Hammond and Tioga Reservoirs would contribute to the maintenance of downstream water quality. However, it is not considered sufficient to assure that standards would be met on a continuous basis.

17. In order to enhance water quality and maintain the quality standards in the reaches presently degraded by mine drainage, abatement measures consisting of land reclamation and collection and treatment appear necessary.

18. The average annual cost of the abatement plans recommended in a contract study report to FWPCA was estimated at $707,000, amortized over 30 years or $455,000 over 300 years.

19. Elimination of mine drainage would provide substantially increased recreational, sport fishery, and agricultural uses of the Tioga River and would result in improved water quality for recreational use of the proposed Tioga Reservoir. In addition, a reduction in construction, operation, and maintenance costs of the Tioga-Hammond Dams could be realized. Estimated benefits attributable to the mine drainage abatement program are valued at about $303,000 annually.

20. Other benefits which are difficult to estimate but which could accrue from the mine drainage abatement program include:

a. The reduction of damages associated with erosion and corrosion of concrete and metal structures.
b. The increased value of reclaimed mining areas and property adjacent to acid degraded streams.
c. Greater potential for economic growth and development in the areas presently plagued with the mine drainage problem.

21. Implementation of the abatement plan in the Tioga River Watershed could serve to verify costs and effectiveness of suggested abatement measures and could serve as a demonstration model for implementing similar actions in other mine drainage problem areas.

22. To lessen the possibility of inundation and scour of the sludge beds at the Elkland Leather Company during peak flood flows and to minimize adverse effects on the recreational use of the proposed Cowanesque Reservoir, the following alternatives were suggested for further consideration:

a. Raise the dikes around the sludge beds to increase the degree of protection from flooding, and
b. Initiate a sludge management program to insure the sludge beds located in the flood plain are empty during the winter and spring high flow months.

23. Another concern of the tannery wastes, particularly the sludge, was the possibility of pathogenic organisms, from the hides of diseased animals, surviving the treatment process. However, it was concluded that the probability of organism survival was remote as a result of the tannery processing methods and the high pH maintained in the processing and waste treatment facilities. Nevertheless, a sampling program to verify the absence of these organisms appears warranted prior to operation of the proposed reservoir.

24. Nutrients and color discharged by the tanneries at Westfield and at Elkland pose potential problems to the recreational usage of the Cowanesque Reservoir. Appropriate treatment facilities are necessary to reduce residual color in the waste stream. Postoperative surveillance measures should be undertaken to determine nutrient levels in the reservoir and to initiate corrective action if there is indication of eutrophication attributable to the tannery wastes.

III. PROJECT DESCRIPTION

LOCATION

Two reservoir sites in the upper portion of the Tioga-Chemung River Basin are presently being considered by the Corps of Engineers for multi-purpose development for flood control, recreation, and flow regulation for water supply and water quality control (see Figure 1).

The Tioga-Hammond Reservoir Project is comprised of two separate dams located on the Tioga River and Crooked Creek, respectively. Present planning provides for a flood control channel to be constructed between the two reservoir pools at a pre-set elevation. Water from either pool could be diverted through the channel in case of flood conditions in either the Tioga River or Crooked Creek. The Tioga-Hammond Project is located approximately seven miles south of the Pennsylvania-New York Border, in Tioga County, Pennsylvania.

The Cowanesque Reservoir Project is located on the Cowanesque River approximately three miles upstream from the point where the Cowanesque joins the Tioga River. The Cowanesque Reservoir is also located in Tioga County, witnin the Commonwealth of Pennsylvania.

STREAMFLOW

The proposed Tioga-Hammond Reservoir Project would control runoff from 400 square miles of drainage, 280 square miles from the Tioga River and 120 square miles from Crooked Creek. The average annual discharge of the Tioga River at the Tioga gaging station at the Project site is 333 cfs, with a minimum flow of 4.5 cfs and a maximum flow of 39,000 cfs, based on 24 years of record. For Crooked Creek, the average annual discharge at the Project site is 112 cfs, with a minimum flow of 2.1 cfs and a maximum flow of 10,900 cfs, based on nine years of record.

The proposed Cowanesque Project would control runoff from a drainage area of 298 square miles. The annual average discharge of the Cowanesque River, at the Lawrenceville gaging station immediately downstream from the Project site, is 290 cfs, with a minimum flow of 0.8 cfs and a maximum flow of 18,300 cfs, based on 11 years of record.

WATER QUALITY

Tioga River and Crooked Creek

Water quality sampling investigations from June to November 1965 and 1968 indicate that municipal and industrial pollution in the Tioga River at the Project site is relatively minor. Sampling records show dissolved oxygen (DO) values of 7 to 12 mg/l in the reach above the Project site. However, mine drainage adversely affects the Tioga River over a 38-mile section from Blossburg, Pennsylvania, to the confluence with the Canisteo River, approximately 16 miles downstream from the Project site. The Federal Water Pollution Control Administration's 1965 and 1968 sampling records immediately upstream from the Project site show pH values ranging from 3.0 to 5.5 (usually 4.0 or greater), total iron concentrations ranging from 0.1 to 5.7 mg/l, and manganese concentrations that occasionally exceed 4 mg/l. A biological survey conducted in this 38-mile reach between July and October 1965 indicated that the stream was generally devoid of benthic organisms and fish life. Conversely, the water quality of Crooked Creek is conducive to fish and aquatic life propagation. Mine drainage is non-existent in Crooked Creek; hence, negligible manganese and iron concentrations prevail, while the pH varies between 6.2 and 9.4. Hardness values range from 40 mg/l to 141 mg/l.

Cowanesque River

The 1965 investigations indicated localized impairment to water quality, primarily downstream from the Boroughs of Westfield and Elkland, Pennsylvania. Sampling results during the late summer months exhibited dissolved oxygen values as low as 2 mg/l downstream from each of these areas but indicated recovery taking place in the vicinity of the reservoir site. Sampling results at the Project site exhibited dissolved oxygen values in the range of 5 to 10 mg/l. The presence of heavy algal growths was noted in the stream during a more recent investigation (October 1968) in the vicinity of Elkland and extending downstream to the confluence with the Tioga River.

TABLE 1

ELEVATIONS AND STORAGE VOLUMES FOR THE PROPOSED PROJECTS

	Tioga Reservoir		Hammond Reservoir		Cowanesque Reservoir	
	Elevation (feet)	Total Storage (acre-feet)	Elevation (feet)	Total Storage (acre-feet)	Elevation (feet)	Total Storage (acre-feet)
Spillway Crest	1,131	62,000	1,131	63,000	1,120	95,490
Cross-over Flume	1,115	39,000	1,115	38,000	---	---
Summer Pool	1,085	11,710	1,085	8,210	---	---
Winter Pool	1,060	2,200	1,075	2,800	---	---
Stream Bed	1,031	0	1,047	0	1,000	0

IV. STUDY AREA DESCRIPTION

LOCATION AND BOUNDARIES

The study area for the proposed Tioga-Hammond and Cowanesque Reservoir Projects contains all of the Tioga River and Chemung River Basins, including the Cowanesque, Canisteo, and Cohocton tributary Watersheds (see Figure 1).

The Project study area has a watershed area of approximately 2,530 square miles, of which 690 square miles are in the Commonwealth of Pennsylvania. Included within the boundaries of the study area are parts of Bradford, Potter, and Tioga Counties in Pennsylvania, and parts of Allegheny, Chemung, Livingston, Ontario, Schuyler, Steuben, and Yates Counties in New York. The Chemung River Basin is bounded by the Finger Lakes of New York on the north, by the Susquehanna River Basin on the east, by the West Branch Susquehanna River Basin on the south, and by the Genesee and Allegheny River Basins on the west.

The major tributaries of the Chemung River are the Tioga and Cohocton Rivers. The Tioga River, with its headwaters in the western portion of Bradford County, Pennsylvania, flows in a southwesterly direction into Tioga County, Pennsylvania, and, thence in a northerly direction to join the Cohocton River at Painted Post, New York. The total length of the Tioga River is 58 miles, of which 46 miles are in Pennsylvania. The major tributaries of the Tioga River are Crooked Creek, Canisteo River, and Cowanesque River. The Cohocton River originates in Livingston County, New York, and flows in a southeasterly direction for a distance of 55 miles to join the Tioga River in forming the Chemung River. From the confluence of the Tioga and Cohocton Rivers, the Chemung River flows 45 miles in a southeasterly direction to the Susquehanna River.

GEOGRAPHY

Located within the Allegheny Plateau physiographic province, the study area is characterized by broad, wide valleys and steep, rounded hills. Shale and sandstone, along with coal in the upper Pennsylvania portion of the study area, are the dominant geological formations. Most of the stream channels in the study area are bordered by wide, alluvial flood plains containing deposits of glacially derived boulders and gravel. Stream gradients vary from 90 feet per mile to two feet per mile.

Many of the alluvial valleys are devoid of tree cover, and their capability to store rainfall has diminished, despite extensive reforestation in recent years. In contrast, the hills in the study

area are steep, rugged, uncultivated, and heavily wooded. Heavy runoff from the steep hills, coupled with the decreased ability of the valleys to hold rainfall, causes extreme flow variations in the study area. Flood control works are evident throughout the study area. Two single-purpose reservoirs and a number of local flood control projects (such as levees, flood walls, and channel improvements) have been constructed to provide flood protection for parts of the study area.

CLIMATE

Annual precipitation within the study area, based on 70 years of record, is approximately 30 to 40 inches. Rainfall intensities fluctuate as much as stream flows, with a maximum value of 12 inches in 48 hours recorded. The mean temperature is 48° F., with a mean monthly low of 26° F. occurring in January and a mean monthly high of 71° F. occurring in July.

PRINCIPAL COMMUNITIES AND INDUSTRIES

Principal communities within the study area are the Boroughs of Mansfield, Westfield, and Elkland in Pennsylvania; the Village of Bath, and the Cities of Elmira, Corning, and Hornell in New York.

The largest industries in the Chemung River Basin are the Corning Glass Works at Corning, New York, and the Great Atlantic and Pacific Tea Company, Ann Page Division, at Elmira, New York. Smaller industrial establishments within the study area are the Ingersoll-Rand Company at Painted Post, New York; the Sperry-Rand Corporation at Elmira, New York; the Bendix Corporation at Elmira, New York. In addition, the New York State Electric and Gas Corporation has a steam-electric generating station located at East Corning, New York.

V. WATER RESOURCES OF THE STUDY AREA

QUANTITY

Information from the U. S. Geological Survey indicates that groundwater sources within the study area are numerous. Underlying or within a mile of most of the major water users are glacial lake and stream deposits of sufficient thickness to provide wells with yields of 500 to 9,000 gpm.

The study area has a humid climate, providing a large supply of water; and there is no foreseeable overall shortage. The groundwater resources appear to be ample to meet the expected future needs; however, the problems that develop may be those of seasonal availability of [illegible] of the total resource.

Surface water flows in the Chemung River Basin demonstrate distinct seasonal variations. Average to high discharges prevail from November through June, with low flow conditions existing during the months of July through October.

Flows in the various streams of the study area show considerable fluctuation. The variation is due, in part, to the rapid runoff from the steep hills and the lack of cover in the alluvial valleys and the physical size of the individual streams themselves. Streamflow characteristics for various locations on the major streams in the study area are given in Table 2.

QUALITY

Information from the U. S. Geological Survey indicates that groundwater quality in the study area is characteristically hard, with concentrations of 200 to 300 mg/l not uncommon in many wells. Excessive iron and/or chloride concentrations are a problem locally, but their occurrence in groundwater from glacial deposits is rare. Ranges in values for important groundwater quality indicators, provided from unpublished information in files of the U. S. Geological Survey, are summarized in the following Table. The 25, 50, and 75 percent values are extracted from a normal frequency distribution of available chemical analyses of groundwater in the upper Susquehanna River Basin.

TABLE 2

STREAMFLOW CHARACTERISTICS

Location	Years of Record	Drainage Area (sq. mi.)	Mean Flow (cfs)	7-Day Mean Low Flow (cfs)* Frequency 10-Year	25-Year
Tioga River at Tioga	24	282	333	7.7	5.7
Crooked Creek at Tioga	9	122	112	2.4	---
Cowanesque River at Lawrenceville	11	295	290	2.0	---
Tioga River at Lindley	30	770	812	15	9.1
Canisteo River at West Cameron	24	342	358	16	13.3
Tioga River at Erwins	42	1,370	1,380	34	27
Cohocton River at Campbell	42	472	452	22	14.2
Chemung River at Chemung	54	2,530	2,530	92	78

* See Appendix C for additional Duration-Frequency Data.

IMPORTANT GROUNDWATER QUALITY INDICATORS*

Indicator	25%**	50%**	75%**
Iron	0.04	0.10	0.30
Manganese	0.01	0.01	0.05
Sulfate	25	30	50
Chloride	10	15	25
Nitrate	0.25	1.0	2.1
Dissolved Solids	190	250	340
Hardness	150	200	225
pH	7.3	7.5	7.8

* All values except pH in mg/l.

** Percentage of wells for which indicator concentrations are equal to or less than the value shown.

The Tioga River, originating in Bradford County, Pennsylvania, is classified as a trout stream. Flowing northward through Tioga County, however, the stream receives mine drainage from several small tributaries. Virtually no biological or fish life exists in the stream reach from Blossburg, Pennsylvania (Stream Mile 86.5), to the confluence with Canisteo River in New York (Stream Mile 48.7). Figures 2 and 3 illustrate profiles of mean concentrations of mine drainage constituents sampled in the Tioga River. (NOTE: Net alkalinity, as shown in Figures 2 and 3, is the difference between the acidity titration to a pH of 8.3 and the alkaline titration to a pH of 4.5; the difference being positive for alkaline water and negative for an acidic water.) Although alkaline water from Crooked Creek discharges to the Tioga River at Stream Mile 65.2, the alkalinity of the smaller flow in Crooked Creek is not sufficient to neutralize the acidity in the Tioga River. Appendix E contains water quality data from the 1965 investigations for selected stations in the Chemung River Basin.

The water quality of the Tioga River is enhanced by the flow from Canisteo River; acidity is apparently reduced through neutralization by the alkaline water from the Canisteo. Biological survey results indicated aquatic life was reappearing, and this reach downstream to the confluence with the Cohocton River exhibited the best biological conditions in the Tioga River in the reaches downstream from Blossburg.

The water quality of the Cowanesque River is intermittently affected by dissolved oxygen levels as low as 2 mg/l, 5-day BOD values as high as 74 mg/l, and abnormally high chloride concentrations

(up to 400 mg/1), particularly near the Boroughs of Westfield and Elkland, Pennsylvania (see Appendix E). However, downstream from these areas the Cowanesque River apparently recovers from the organic waste loadings prior to discharge to the Tioga River at Mile 57.6. Tanneries at Westfield and Elkland contribute significant inorganic loadings to the stream. For example, the tannery at Elkland contributed as much as 938 mg/1 of sulfate, 37.5 mg/1 of calcium, and 1.1 mg/1 of iron to the stream during the 1968 sampling investigation. Also, during the investigation, the stream exhibited profuse algal growths downstream from the tanneries at both Westfield and Elkland.

The water quality of the Canisteo River is degraded by inadequately treated municipal and industrial wastes at several locations. One 10-mile section of the Canisteo River below Hornell, New York, shows almost no dissolved oxygen, with sludge deposits and gassing readily apparent at times (see Appendix E). Recovery appears to be complete approximately 16 miles downstream from Hornell at Adrian, New York. The Canisteo River contributes satisfactory water quality to the Tioga River at Mile 48.7.

The Cohocton River experiences localized degradation from municipal and industrial discharges from the Villages of Cohocton, Bath, and Painted Post; discoloration, sludge deposits, floating solids, and oil have been reported[1] at several locations. However, during the 1965 sampling of Cohocton River, the limited data exhibited quality conditions normally associated with undegraded streams (see Appendix E).

Localized degradation of the Chemung River occurs downstream from the Village of Painted Post and the Cities of Corning and Elmira. Stormwater relief sewers discharge into the Chemung River at the Cities of Corning and Elmira. Despite discharges of treated and untreated municipal and industrial wastes, the Chemung River (during the 1965 and 1968 sampling periods) exhibited dissolved oxygen concentrations usually greater than 5 mg/1, except in the reaches downstream from Newtown Creek and Elmira's sewage treatment plant where DO values below 5.0 mg/1 were more frequent. During the 1965 sampling, the 5-day BOD concentrations downstream from Elmira ranged as high as 33 mg/1; however, the 1968 sampling results yielded 5-day BOD values up to about 6.8 mg/1. The bacteriological results indicated coliform densities in the range of 10,000 to 800,000 count per 100 ml.

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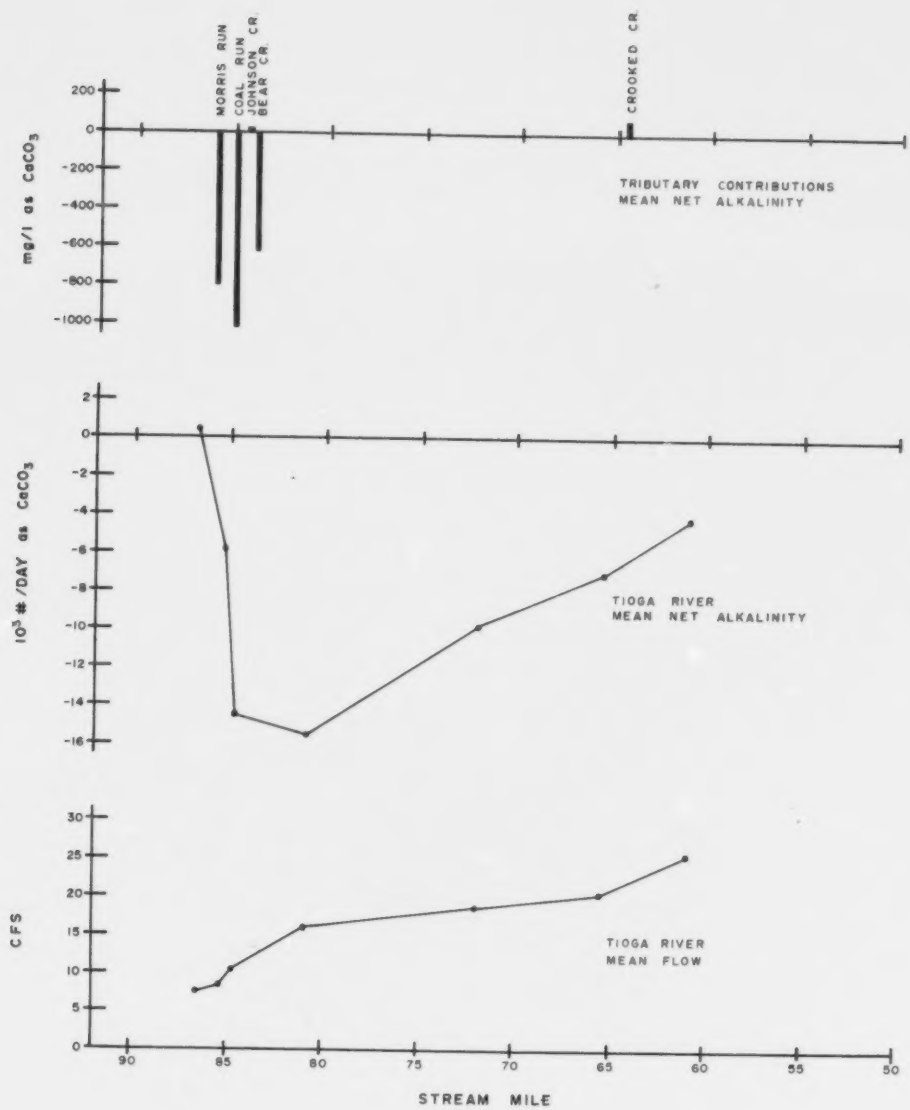
[1] Chemung River Drainage Basin Survey Series Report No. 2, New York State Department of Health.

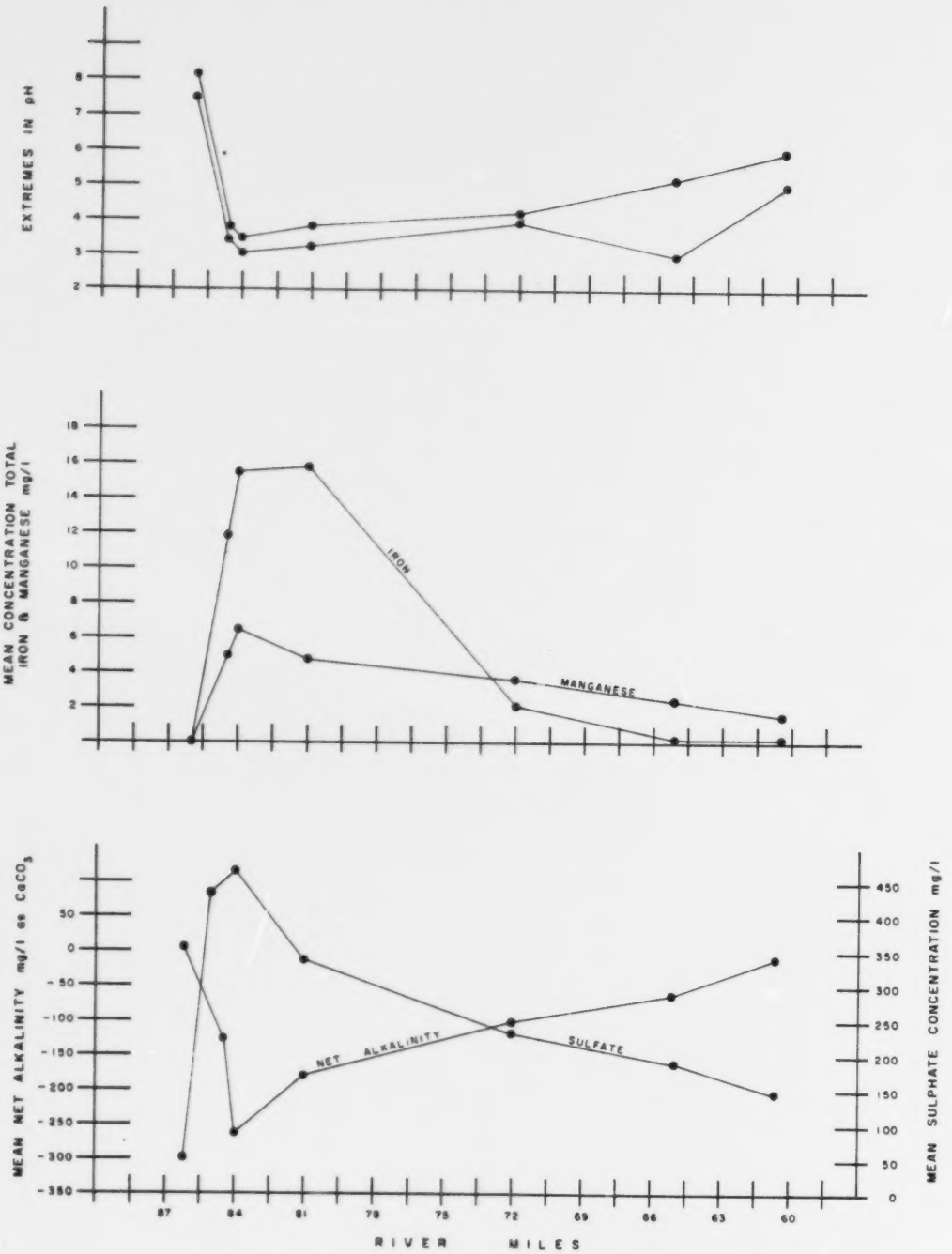
The absence of swimming and bathing areas utilizing the surface waters of the Chemung River Basin seems to indicate general recognition that the quality of the water is not suitable for water-oriented recreation. Other water uses, though demanding lower quality, appear to be satisfied by the present water quality.

Two single-purpose reservoirs are located in the study areas. The Arkport Reservoir is located on the Canisteo River approximately one mile west of Arkport, New York. The Almond Reservoir is located on Canacadea Creek, a tributary of the Canisteo River, approximately two miles northeast of Almond, New York. Until 1965, both reservoirs provided storage for flood control only; however, beginning in the summer of 1965, operations of the Almond Reservoir were changed to provide a recreation pool, with a difference of about 500 acre-feet between normal summer level and the lower normal winter level. The fall drawdown to winter level increases natural streamflow by about 8 cfs for 30 days, beginning in mid-September.



PROFILE OF FLOW, NET ALKALINITY OF TIOGA RIVER
AND
TRIBUTARY CONTRIBUTIONS OF NET ALKALINITY

FIGURE 2



PROFILE OF pH, MANGANESE, IRON & SULFATE CONCENTRATION AND NET ALKALINITY

TIOGA RIVER

FIGURE 3

VI. THE ECONOMY

INTRODUCTION

For the purpose of economic analysis, the study area consists of Steuben and Chemung Counties in New York and Potter and Tioga Counties in Pennsylvania. The two main urban areas are Elmira in Chemung County and Corning in Steuben County. The area is slightly more than 150 miles from New York City, Philadelphia, and Pittsburgh, and within approximately 50 miles of Buffalo and Rochester.

PRESENT ECONOMY

The largest City in the study area, Elmira, is located along the Chemung River approximately 26 miles upstream from the confluence with the Susquehanna River, in the midst of an extensive valley complex suitable for future urban expansion. The New York Counties of Chemung and Steuben contain considerably more lowland area than do the two Pennsylvania Counties. Consequently, remaining forestation is only about 33 percent in Steuben County and 45 percent in Chemung; compared with almost 66 percent in Tioga and 90 percent in Potter County.

In 1964, approximately 500 persons were employed in lumbering. Non-forest agricultural uses varied inversely to the degree of forestation. Steuben County had the greatest percentage of acreage (over 65 percent) in such non-forest agricultural uses, with heavily forested Potter County having only nine percent. Steuben County contains the major concentration of dairy operations as well as orchards, vineyards, and general farming in the extreme north of the County. Broilers are extensively raised in Tioga County.

Railroads connect major centers in the Sub-basin with the main industrial and population centers of the northeast part of the United States. Elmira, New York, is the railway hub of the area, being served by the Erie-Lackawanna-Western and the Penn Central Railroads.

U. S. Highways 6 and 15 and State Routes 13, 14, and 17 are the major highways connecting the population centers within the study area and also linking the urban centers to large areas in New York and Pennsylvania.

Between 1940 and 1950 and again from 1950 to 1960, population in the study area increased by only about eight percent. The population of Chemung County increased substantially more than the average (18 percent in 1940-1950, 14 percent in 1950-1960) while, on the other hand, Steuben County's growth was somewhat slower than

the average for the total study area, partly as a result of production decreases at the Corning Glass Works plants. The population of Tioga County increased only slightly; while Potter County, the most rural County in the study area, actually decreased in population over the period 1940-1960. The area as a whole was subject to net outmigration.

FUTURE ECONOMY

National Planning Association projections of employment and population, on the basis of economic prospects, show a considerably faster rate of growth in the coming decades than in the past. Calculated for an economic sub-region somewhat larger than the study area (about 50 percent larger in population), these projections show 10-year increases ranging from 20 to 27 percent over the 60-year (1960-2020) projection period. These increases place the study area as the fastest growing economic sub-region in the Susquehanna River Basin over the full 60-year period and second in rate of growth in the 1960-1990 period.

The study area should match expected performance on the basis of the comparative performance of Chemung and Steuben Counties. Population of the study area may be expected to increase by over 80 percent between 1960 and 1990, from 250,000 to 458,000. Much of the growth is expected to occur in the more industrialized New York Counties, but Tioga County is also expected to show some gain over past growth.

The two largest Cities, Elmira, New York, with a 1960 population of 46,517, and Corning, New York, with a 1960 population of 17,085, should lead the population growth. The potential water service areas (concentrated water use areas expected to act as nuclei for future growth) were each about twice as populous as the Cities proper in 1960, and these areas are projected to double in population in 30 years. (See Appendix D, Table D-1.) Much slower growth is projected for the municipal area of Hornell, New York, the third largest City.

Tabulated on the following page is a summary of the present and projected population for the water service areas within the study area.

Water Service Area	Present Population	Projected Population 1980	2000	2020
Bath	11,978	22,000	37,000	64,000
Corning	36,172	58,000	91,000	149,000
Elkland	3,088	3,800	4,600	5,900
Elmira	97,421	163,000	264,000	441,000
Hornell	20,972	25,000	28,000	34,000
Mansfield	4,029	5,800	8,600	13,000
Westfield	2,369	2,992	3,622	4,645

The rapid rate of increase in population, based on increased economic expansion, implies that a substantial net in-migration of working-age population and their families will occur in the study area through the year 2020. A list of industries for the area and projections of output is provided in Appendix D, Table D-2.

VII. MUNICIPAL AND INDUSTRIAL WATER SUPPLY

PAST AND PRESENT WATER USES

Municipal

Within the Tioga and Chemung River Basins are 36 privately or publicly owned water utilities currently supplying the municipal water needs of the study area (see Appendix A, Table A-1). Summarized below are the sources of water, present population served, and average daily use for these 36 municipal water utilities.

Source of Water	Population Served	Average Use (mgd)	Average Use (gpcd)
Ground Water	72,800	9.56	132
Surface Water	88,900	9.96	112
Total	161,700	19.52	121

Almost 85 percent of the public water needs in the Tioga River and Chemung River Basins is provided by three municipal water utilities: the Corning Water Works, the Elmira Water Board, and the Hornell Municipal WAter Works.

Below Elmira, New York, the only major municipal water utility is Waverly, New York, located near the confluence of the Chemung and Susquehanna Rivers. Waverly obtains its water supply from two impoundments in Dry Brook, a tributary to the Chemung River.

Industrial

Approximately 80 percent of the water supplied in the Tioga River and Chemung River Basins is used to satisfy industrial water needs. Listed in Appendix A, Table A-2, are the industrial water users in the study area. The sources of water and average daily consumption for these industrial water users are as follows:

Source of Water	Average Daily Use (mgd)	Percent of Total
Ground Water	13.62	21.1
Municipalities	5.75	8.9
Surface Water	45.20	70.0
Total	64.57	100.0

A breakdown of the industrial water usage in the Tioga River and Chemung River Basins is tabulated below.

Used by Industry	Average Daily Use (mgd)	Percent of Total
Potable Water	1.57	2.4
Process Water	11.40	17.7
Cooling Water	51.60	79.9
Total	64.57	100.0

Other

Surface water within the study area is also used for livestock watering in support of the many dairy operations in the Basin. The alluvial valleys provide good grazing land, and the nearby streams allow livestock easy access to water. Surface water is presently used to a limited extent for agricultural irrigation. Estimates[2] of irrigation water indicate approximately 5 cfs are now being used in the Chemung River Basin.

Most of the swimming in the Tioga River and Chemung River Basins is done on an individual basis. Supervised swimming is carried out at municipally operated bathing areas on Bennetts Creek in the vicinity of Canisteo Village and on the Cohocton River at Cohocton Village.

Sport fishing in the Chemung River Basin is primarily for warm-water species such as bass, pike-perch, pickerel, and the various panfishes. Bass are generally numerous but slow growing, and an eight-inch minimum size limit prevails in the main river and tributaries upstream from Corning, New York. Trout fishing is restricted to some of the smaller tributaries and the headwaters of Canisteo and Cohocton Rivers.

EXISTING SOURCES OF GROUND AND SURFACE WATER

In order to facilitate analysis for water supply requirements and waste loads, "water service areas" were established to coincide with geographic concentrations of municipalities and/or industries. Under the water service area concept, such areas can contain urban, suburban, and rural residential areas; unincorporated areas; and

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[2] Irrigation Report (Preliminary), Susquehanna River Basin, U. S. Department of Agriculture, Soil Conservation Service, Harrisburg, Pennsylvania, June 1966.

commercial and industrial complexes. These areas of concentrated use are expected to act as nuclei for future growth in the study area. By including the major municipalities and industries in one water service area or another, all of the significant water users and waste producers are encompassed in the determination of water supply requirements and waste loads. While at the present time only a small percentage of the total population in any water service area is served by central water systems, past experience indicated that with growth and development in the future, an increasingly higher percentage of the population of all water service areas can be expected to be connected to central systems. For planning purposes, it is considered reasonable to provide for all water needs in the water service areas by the year 2020.

Seven water service areas were established for the purpose of evaluating the water supply requirements and waste loads of the study area. The seven areas designated include: Mansfield on the Tioga River, Elkland and Westfield on the Cowanesque River, Hornell on the Canisteo River, Bath on the Cohocton River, and Corning and Elmira on the Chemung River.

QUANTITY

The sources and quantity of municipal water supplies presently used in each of the seven water service areas are given in Table 3.

TABLE 3

PRESENT MUNICIPAL WATER SUPPLY

Water Service Area	Population Served	Source of Supply: Ground Water (mgd)	Source of Supply: Surface Water (mgd)	Average Demand (gpcd)
Mansfield	4,400	0.00	0.26	59
Westfield	1,200	0.14	0	117
Elkland	2,180	0.15	0	69
Hornell	18,350	0.42	1.87	125
Bath	5,000	0.49	0	98
Corning	24,300	2.63	0	108
Elmira	78,616	3.78	6.37	129
Total	134,046	7.61	8.50	120

As indicated by Table 3, four water service areas, Westfield, Elkland, Bath, and Corning, rely solely on ground water sources for meeting their present municipal water supply needs. Of the other three water service areas, Mansfield uses surface water sources exclusively for its municipal water supply, while Hornell and Elmira acquire most of their municipal water supply from surface water sources.

Table 4 indicates the source and quantity of industrial water supplies presently used in each of the seven water service areas.

TABLE 4

PRESENT INDUSTRIAL WATER SUPPLY

Water Service Area	Source of Supply		
	Ground Water (mgd)	Surface Water (mgd)	Municipal Water (mgd)
Mansfield*	---	---	---
Westfield	0.42	---	---
Elkland	---	2.0	---
Hornell	---	---	0.39
Bath	---	---	0.20
Corning	5.45	---	2.84
Elmira	6.91	---	1.88
Total	12.78	2.0	5.31

* Negligible industrial water supply requirements.

In addition to the industrial water supply needs of Table 4, the New York State Electric and Gas Corporation maintains a steam-electric generating plant on the Chemung River about four miles downstream from the Corning area. Present water usage at this plant amounts to about 43.2 mgd.

Ground water resources are currently used to satisfy approximately one-third of the needs of seven water service areas. Significant undeveloped potential is believed to exist, however, and ground water can be expected to be utilized more in the future to satisfy larger demands at each service area.

In addition to ground water resources, there exists an almost untouched surface water supply potential in each of the water service areas except Hornell, Corning, and Elmira.

QUALITY

Ranges in values for ground water indicators were listed previously on Page V - 3. These values are generally typical of the ground water quality in the study area. High hardness concentrations (200 to 300 mg/l) are characteristic in the ground waters of each of the seven water service areas.

Surface water quality in the study area varies with the proportion of ground water in the base flow. During periods of low flow, surface water has quality characteristics similar to those of ground water because of the great contributions of ground water to stream flow. As indicated previously in Section V, water quality is adversely affected because of organic or mine drainage pollution at various locations throughout the Chemung Basin.

FUTURE WATER REQUIREMENTS

Municipal

It is believed that municipal water needs in the future will fluctuate according to the economy, availability of water, size of the municipality, living standards, and topography. Other factors, such as meter installation, degree of industrialization, and water quality are also expected to exert some influence on future municipal water requirements.

National water use trends as well as water use trends for the study area suggested a 1.0 percent annual increase in the per capita water use was reasonable for planning purposes; therefore, a 1.0 percent annual increase in per capita water use was used to project the municipal water requirements of the study area to the year 2020. The projected municipal water supply needs for the seven water service areas are presented in Table 5.

Industrial

Generally, industry is classified as either wet or dry, depending on the quantity of water required for operation. Wet industries utilize a significant amount of water for operation; the actual quantity varying with the plant location, size, availability of water, product mix, recirculation, and the particular industrial process. Dry industries require little or no water in their operation.

Estimates of future industrial water use requirements are based on National Planning Association projections of industrial development for economic sub-regions. These projections provide

TABLE 5

PROJECTED MUNICIPAL WATER NEEDS

Water Service Area	Projected 1980 Population Served	1980 mgd	1980 gpcd	Projected 2000 Population Served	2000 mgd	2000 gpcd	Projected 2020 Population Served	2020 mgd	2020 gpcd
Mansfield	6,400	0.44	69	9,500	0.77	81	14,000	1.3	93
Westfield	2,000	0.26	130	3,000	0.46	154	4,700	0.8	165
Elkland	3,100	0.25	80	4,200	0.42	93	5,900	0.6	107
Hornell	22,750	3.32	146	26,900	4.6	171	34,000	6.7	196
Bath	13,200	1.5	115	29,600	4.0	134	64,000	9.9	154
Corning	44,650	5.6	126	81,000	12.0	148	149,000	25.3	170
Elmira	141,800	21.4	151	248,200	43.9	177	441,000	89.5	203
Total	233,900	32.8	141*	402,400	66.2	157*	712,600	134.1	188*

* Mean.

indices of productivity in each of the four-digit Standard Industrial Classification codes, employing a base index of 100 for present productivity and employment. Present industrial water consumption, obtained from inventories and personal contacts, is multiplied by the indices of productivity to obtain estimates of future water requirements for the years 1980, 2000, and 2020. These projected requirements were then attenuated to reflect possible reductions in use rates by application of water-saving techniques such as process or equipment modification, cooling towers, and recirculation.

The major change in the industrial water use within the study area will be the phasing out of operation of the New York State Electric and Gas Corporation's Hickling Station downstream from Corning. As indicated by company officials, phasing out will be completed by about 1990.

Currently the water needs (43.2 mgd) of the New York State Electric and Gas Corporation comprise approximately 70 percent of the industrial water requirements of the study area. Until 1990, the Hickling Station plant's water needs are expected to remain constant.

The projected water requirements for the major water-using industries in or near the seven water service areas are as follows:

Water Service Area	Present (mgd)	Projected 1980 (mgd)	2000 (mgd)	2020 (mgd)
Mansfield*	---	---	---	---
Westfield	0.42	0.17	0.04	0.02
Elkland	2.00	0.66	0.24	0.23
Hornell	0.15	0.59	0.93	1.3
Bath	0.20	1.2	2.5	3.5
Corning	8.29	13.3	17.7	22.7
New York State Electric and Gas Corporation	43.2	43.2	**	---
Elmira	7.30	34.3	63.6	82.7

* Negligible industrial water requirements.

** New York State Electric and Gas Corporation considered to be out of operation by 1990.

Table 6 summarizes the total present and projected water supply needs for each of the water service areas as well as presents the estimated 7-day, 25-year flow of the stream at each service area.

TABLE 6

MUNICIPAL AND INDUSTRIAL WATER SUPPLY NEEDS

Water Service Area	Present Water Supply Needs (mgd)	Projected Water Supply Needs (mgd)			Natural Stream Flow (Min. 7-day Flow) Once in 25 Years		
		1980	2000	2020	River	cfs	mgd
Mansfield	0.26	0.44	0.77	1.3	Tioga	2.0	1.29
Westfield	0.56	0.43	0.50	0.79	Cowanesque	1.5	0.97
Elkland	2.15	0.91	0.66	0.86	Cowanesque	3.0	1.94
Hornell	2.69	3.9	5.5	7.9	Canisteo	9.5	6.1
Bath	0.69	2.8	6.5	13.4	Cohocton	12.3	7.85
Corning	10.92	18.9	29.7	48.0	Chemung	65	42
New York State Electric and Gas Corporation	43.2	43.2	*	---	---	---	---
Elmira	18.94	55.7	107.5	172.2	Chemung	66.6	43.0

* New York State Electric and Gas Corporation steam-electric power plant considered to be out of operation by 1990.

As indicated by Table 6, two water service areas, Elkland and Westfield, have sufficient natural stream flow which could be used to satisfy the projected needs for water supply. At present, though, the Elkland and Westfield water service areas rely solely on ground water for their sources of supply. Because of availability, both of these water service areas are expected to utilize additional ground water development to meet future water supply needs. In the event future development of ground water resources does not prove to be feasible in either or both of these water service areas, surface water supplies should be ample to satisfy the projected water supply requirements. The Mansfield water service area currently draws its water supply from surface water sources other than the Tioga River. It is anticipated that existing and potentially available surface water supplies will be more than adequate to satisfy projected needs in the Mansfield water service area.

In the Bath water service area, ground water sources are used exclusively to meet the present water supply requirements of 0.69 mgd. These existing sources, along with the natural stream flow in the Bath water service area, are expected to be inadequate for meeting the 2020 average water supply need of 13.4 mgd. Further development of ground water resources or reservoir storage to provide about 5 mgd in excess of the natural stream flow will be necessary to satisfy the average water supply requirements by the year 2020. Flow regulation from the proposed Tioga-Hammond and Cowanesque Projects is not expected to be utilized to satisfy future water supply requirements at Bath, unless it is determined feasible to convey water by pipeline from the Chemung River (a distance of about 20 miles). The Corps of Engineers has studied three potential multi-purpose reservoir sites in the Cohocton River Watershed; hence, possible storage at any one of the reservoir sites which may be developed should be evaluated as an alternative to further ground water development or pipeline from the Chemung. However, it is expected that ground water could adequately meet the projected needs. Any source development should be adequate to satisfy estimated maximum daily demands of 20.1 mgd and maximum monthly demands of 16.7 mgd.

The Hornell water service area presently obtains nearly all of its 2.44 mgd water supply needs from an impoundment on Carrington Creek. By the year 2020 the Hornell water service area anticipates an average water supply requirement of 7.9 mgd. Existing surface water supplies combined with natural stream flow of the Canisteo River are not expected to be adequate to satisfy the 2020 needs. Either development of ground water resources or reservoir storage to provide approximately 3.5 mgd would be needed to satisfy average requirements. As in the case of Bath, flow regulation from the proposed Tioga-Hammond and Cowanesque Reservoirs does not appear likely, since a pipeline from the Tioga River to Hornell (about 38 miles)

would be required. However, with the abundance of ground water, as reported by the U. S. Geological Survey in the area, further development of ground water resources is expected. Any development should also be capable of meeting short-term peak demands, such as maximum day and month of 11.9 mgd and 9.9 mgd, respectively.

In the Corning water service area, the 10.9 mgd present water supply requirements are supplied by ground water. Existing ground water sources, supplemented by natural stream flows, are adequate to meet 1980, 2000, and 2020 average needs of 18.9 mgd, 29.7 mgd, and 48 mgd, respectively. Evaluation of the ground water resources of the study area indicates significant undeveloped potential exists, and that ground water could be utilized to satisfy larger demands at Corning. The New York Electric and Gas Corporation power generating station downstream from Corning anticipates no increase in water usage prior to phasing out operations by 1990. Therefore, natural stream flows should continue to adequately meet the flow needs of this industry.

Elmira, the largest water service area in the study area, obtains approximately 60 percent of its current 18.94 mgd water supply needs from ground water sources. The remainder of its present supply is provided by the Chemung River and Hoffman Creek. Complete utilization of existing natural stream flow could result in a water supply yield of about 43 mgd; however, this would theoretically create a "dry" reach. The existing sources of supply, including the natural stream flow of the Chemung River, are expected to be marginal or inadequate to meet the average demand of 55.7 mgd by the year 1980, and certainly inadequate to meet the peak demands of 83.5 mgd for the maximum day and 69.6 mgd for the maximum month. By the years 2000 and 2020, additional development would be required to meet both the average daily needs as well as the peak requirements. Maximum daily demands are estimated to be about 162 mgd and 250 mgd by the years 2000 and 2020, respectively, with corresponding maximum monthly needs of about 135 mgd and 215 mgd.

Preliminary estimates by the U. S. Geological Survey indicate that underlying Elmira, as well as the other areas of this report, are vast reservoirs of ground water capable of supplying large quantities of water during drought periods far exceeding anything in the historical record. It is estimated that with a series of wells along lines extending outward from Elmira more than 400 cfs for up to 112 days might possibly be drawn from the underground reservoir. Since this draft is greatly in excess of the reasonable rate of direct recharge by precipitation to the aquifers (approximately 1 mgd per square mile) continual withdrawal from the aquifer would necessitate some scheme of ground water recharge. A series of wells in the two valleys around Horseheads is estimated to yield a potential supply

of 333 cfs for approximately 108 days prior to recharge. The above quantities are rough estimates of the ground water potential in the Elmira area and are based on assumptions and judgments of existing geological and hydrological information. In order to obtain a greater assurance of the ground water potential in the areas, further studies appear necessary. These studies should provide the opportunity to evaluate various alternative schemes of development with an objective toward ultimate development and management of the water resources in the area. If ground water alone were utilized to meet the projected needs for Elmira, an elaborate arrangement would be required for replenishment of ground water aquifers.

The projected water supply requirements for the Elmira area could be met by augmenting the flow of the Tioga-Chemung River from storage in the Tioga-Hammond and Cowanesque Reservoirs. Historical stream flow data were analyzed to evaluate the adequacy of various reservoir storages to meet flow requirements. Stream flow sequences (representing a 500-year period) that preserved the statistical characteristics of the historical data were generated by a high-speed digital program developed by Fiering and Pisano.[3] A single reservoir, controlling the combined watersheds upstream from the three proposed reservoirs, was assumed at the Tioga-Hammond and Cowanesque complex site; and flows were routed through varying sizes of the reservoirs to meet the 1980, 2000, and 2020 water supply requirements of the Elmira water service area.

Storages to meet Elmira's water supply needs for years 1980, 2000, and 2020 were evaluated two ways: (1) total municipal and industrial water supply needs, exclusive of industrial cooling water requirements, and (2) total municipal and industrial water supply requirements, including industrial cooling water (see Table 7).

Based on these analyses, it is estimated that an effective storage of 29,500 acre-feet (exclusive of cooling water) or 37,000 acre-feet (including cooling water) will be needed at the Tioga-Hammond and Cowanesque Reservoirs to meet the 2020 water supply needs at Elmira. Required storages for years 1980 and 2000 are shown in Table 8.

The effective storage selected was based on meeting the stream flow requirements to satisfy Elmira's average water supply needs with a protection level of 98 percent, i.e., the chance of deficiencies occurring in not more than two percent of the years.

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[3] Fiering, M.B., and Pisano, W.C., "Synthesis and Simulation Package for Reservoir Planning," prepared for the Federal Water Pollution Control Administration, U. S. Department of Health, Education, and Welfare, 1966.

TABLE 7

REQUIRED STREAM FLOW TO MEET PROJECTED WATER SUPPLY NEEDS AT ELMIRA*

Year	M & I Needs (Excluding Cooling Water) mgd	M & I Needs (Including Cooling Water) mgd
1980	30.0	45.0
2000	84.0	96.8
2020	143.6	161.5

* Needs are reduced by 10.7 mgd, the present ground water usage at Elmira.

TABLE 8

STORAGE REQUIREMENTS AT TIOGA-HAMMOND AND COWANESQUE RESERVOIRS TO MEET PROJECTED WATER SUPPLY NEEDS AT ELMIRA

Year	M & I Storage (Excluding Cooling Water) Acre-Feet	M & I Storage (Including Cooling Water) Acre-Feet
1980	0	2,700
2000	9,250	12,700
2020	29,500	37,000

The values given in Table 8 represent storage volumes for fully meeting Elmira's projected water supply needs from surface sources. Further development of ground water resources in the area would reduce the reservoir storage needed. The decision to provide storage or utilize ground water resources would, therefore, be based on economics and technical feasibility of each alternative. However, it is expected that future development will result in some combination of reservoir storage and ground water development. Hence, surface water needs are plotted against reservoir storage and presented as Figure 4 in order to facilitate estimating the storage needed if surface water use is reduced by increased ground water utilization. The storage volumes given were computed to provide a 98 percent assurance that the specified flows would be available when needed.

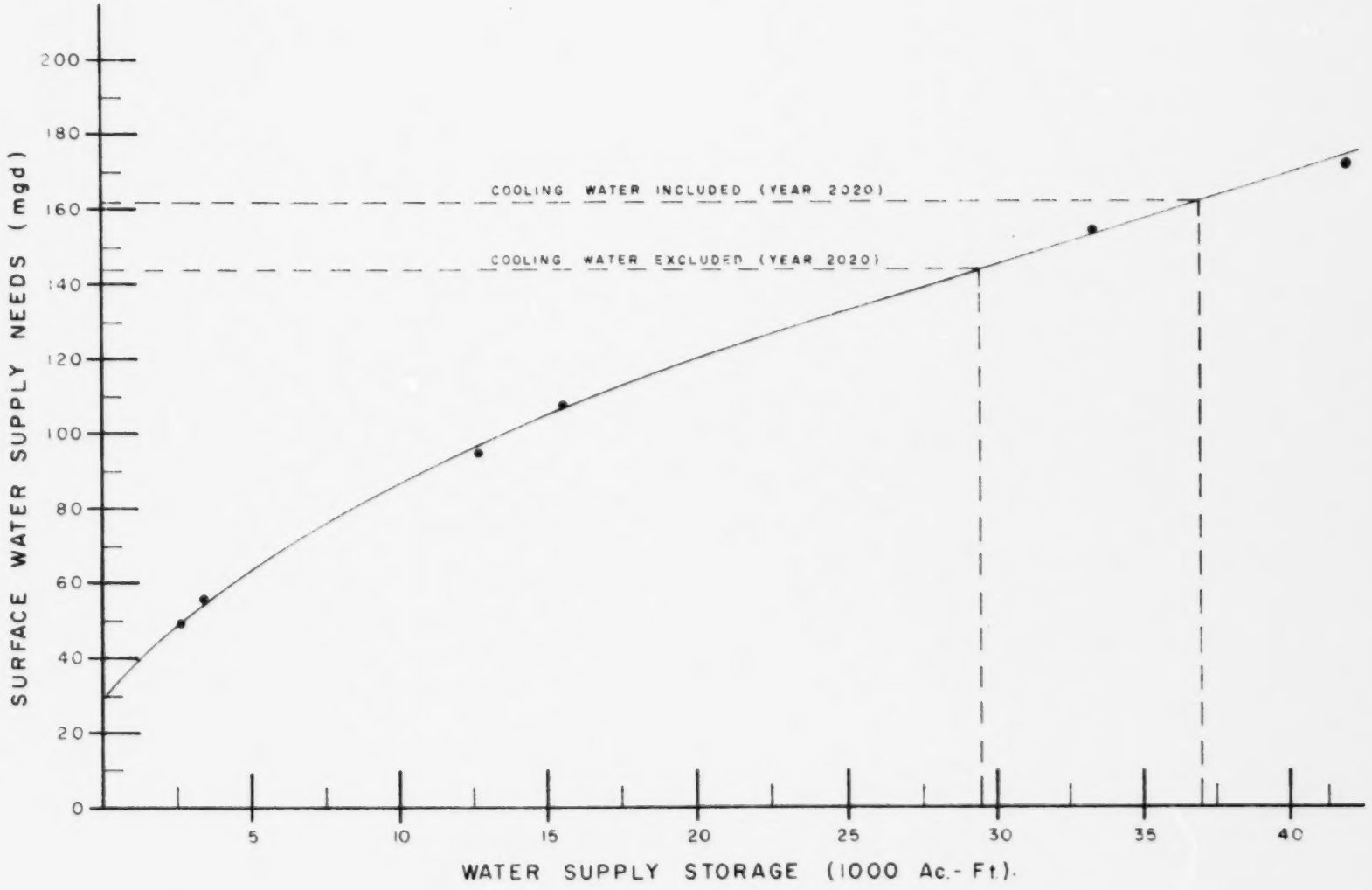


FIGURE 4

SURFACE WATER NEEDS AT
TIOGA - HAMMOND - COWANESQUE SITE
FOR 98% PROTECTION LEVEL AT ELMIRA

VIII. WATER QUALITY CONTROL

Continuing control of water quality is necessary if the beneficial uses of the water resources of the Basin are to be maintained. Without adequate control measures, water quality will be degraded by the wastes normally associated with economic growth and will adversely affect recreation, fish and wildlife, and general aesthetics of area streams. By meeting water quality requirements, waste treatment and flow regulation will assure that the area streams can serve a variety of uses. As a result of better water quality, economic benefits will accrue from less costly treatment for water supplies; from greater opportunity for water-based recreation; from less corrosion of navigation equipment, water structures, and industrial equipment; and from improvements in real estate values.

A stream normally assimilates a limited amount of organic waste through natural biological processes. When the waste load discharged to a stream exceeds the assimilative capacity, additional treatment is needed to maintain its quality. If the water quality remains degraded after adequate waste treatment (presently considered to be well-operated secondary treatment) has been applied, then additional streamflow can be used to ensure that a suitable water quality will be maintained in the stream.

MUNICIPAL AND INDUSTRIAL POLLUTION

The principal sources of waste discharged into the waters of the Tioga River and Chemung River Basins are tabulated in Appendix B, Tables B-1 and B-2. In projecting waste loadings to the year 2020, it is assumed that adequate treatment will be provided at each waste source prior to discharge into a stream. For purposes of this report, adequate treatment is defined as secondary treatment with 85 percent reduction in BOD, since the wastes produced generally will be amenable to reduction in existing biological waste treatment processes. Greater reductions can be obtained on wastes actually reaching secondary treatment facilities, but discharges of organic material through surface runoff and occasional seepage from home disposal systems can result in an overall average reduction in BOD of approximately 85 percent.

Based upon present waste strengths, with adjustments for anticipated future waste discharges, waste loads from municipal sources are estimated to be equivalent to 0.25 pounds of ultimate BOD per person per day. Industrial waste discharges are much more complicated to appraise, however. Even in the manufacture of a single product, the use of different industrial techniques and processing

equipment may result in wide variations in quantity and strength of wastes. Thus, future industrial wastes are estimated either by utilizing present discharge data from individual plants or by applying typical loading data for the industries anticipated.

The present and anticipated waste loadings for each of the seven water service areas are summarized in Table 9.

TABLE 9

MUNICIPAL AND INDUSTRIAL WASTES

Water Service Area	Estimated Waste Flow (mgd)	Present and Anticipated Loadings Ultimate BOD (lbs.)			
		1965	1980*	2000*	2020*
Mansfield	0.34	845	194	310	488
Westfield	0.64	695	103	90	107
Elkland	2.3	1,059	203	205	260
Hornell	2.25	3,220	1,390	1,840	2,410
Bath	0.4	440	690	1,320	2,500
Corning	3.57	6,870	3,400	6,230	9,750
Elmira	7.78	12,900	11,750	21,000	32,400

* Projections assume 85 percent removal of carbonaceous BOD.

The Hickling power generating station near Corning, New York, discharges approximately 43 cfs of condenser cooling water which amounts to about 20 to 50 percent of total stream flow during normal summer flow conditions. While an apparent thermal problem has not developed, this discharge is a factor in limiting the assimilative capacity of the River, particularly during the low flow periods. Present information indicates that this plant will be phased out of operation by year 1990.

In addition to waste loadings from municipal and industrial sources, pollutants enter the streams of the study area from agricultural sources. During periods of high surface runoff, insecticides, pesticides, fertilizers, and barnyard and pasture runoff contribute to the waste that must be assimilated by area streams. Nutrients derived from these sources contribute to algal growth, while solids contribute to the build-up of sludge deposits.

Based upon the provision of secondary treatment, waste loadings from Mansfield, the only water service area upstream from the Tioga-Hammond Project site, are not expected to adversely affect

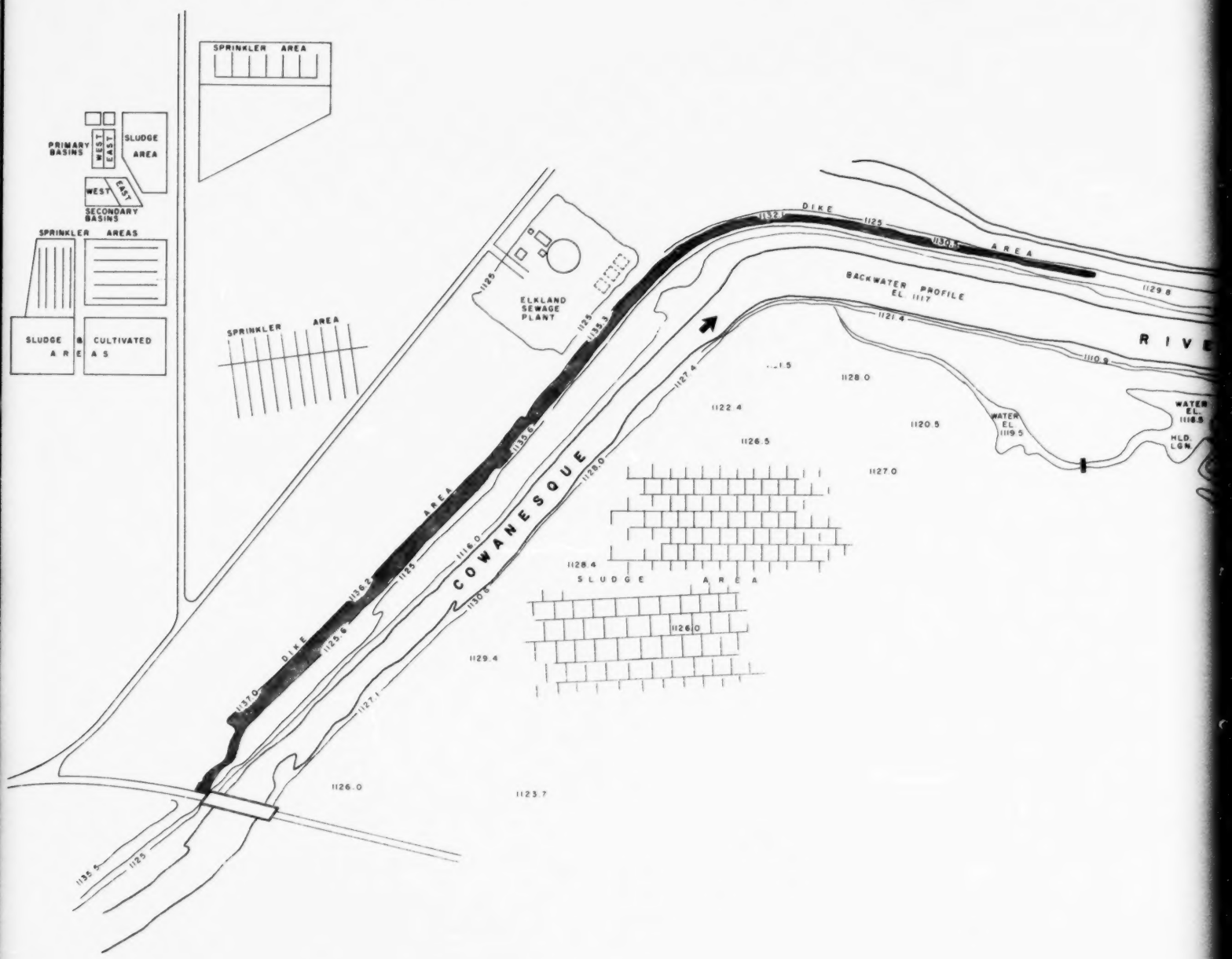
water quality in the Tioga Reservoir. Mine drainage, however, appears to be a significant cause of impairment of water quality in the Tioga River upstream from the Tioga-Hammond Project site.

The Cowanesque River is initially degraded by the discharge of primary effluent from the Borough of Westfield, approximately 23 miles upstream from the proposed reservoir site. A leather tannery located at Westfield provides the equivalent of primary treatment prior to discharging process wastes to the River and adds further to the degraded condition. Although the stream recovers partially in the 13-mile stretch downstream to the Borough of Elkland, it receives additional waste loadings from the secondary treatment facilities at this Borough and from lagoons at a leather tannery located here. Approximately 1 mgd of wastes originating at the tannery undergoes two-stage settling prior to discharge to spray ponds where spray aeration and land application are practiced during daylight hours of the summer months. Excess flows during operation of the spray ponds, and the entire flow during colder months, are retained in holding lagoons located on the opposite side of the River from the plant (see Figure 5). Effluent from the holding ponds is subsequently released in proportion to the river flow when the discharge exceeds 10 cfs, as measured by the USGS gage at Lawrenceville. The allowable releases from the holding ponds have been established by the Pennsylvania Department of Health based on river flow and the BOD of the effluent being discharged. The control procedure permits the discharge of one part effluent per approximately 80 parts of stream flow.

Passage of wastes through the tannery holding ponds results in 50 and 70 percent reduction in BOD, according to data obtained during the period of September 1, 1968, to February 15, 1969; the BOD of the wastes reaching the treatment facilities ranged from 820 mg/l to 1,210 mg/l, whereas effluent BOD ranged from 320 to 440 mg/l.

Data from the 1965 investigations (Appendix E, Table E-3) indicated that dissolved oxygen values as low as 2 mg/l were occurring in the vicinity of the proposed reservoir. Dissolved oxygen concentrations observed October 21, 1968, were higher than were experienced in 1965; however, during the more recent limited sampling, the flow was higher and the temperature lower than would be expected during late summer months. The results of the 1965 investigations indicate that water quality problems are likely in the proposed reservoir unless additional treatment is provided at the tannery at Elkland, at the upstream tannery at Westfield, and at Westfield Borough.

The effluent from the tanneries at both Westfield and Elkland is amber or "cloudy tea" colored and could be aesthetically objectionable in the reservoir. The installation of color removal facilities


SPRINKLER AREA
PRIMARY BASINS
WEST
EAST
SLUDGE AREA
WEST
EAST
SECONDARY BASINS
SPRINKLER AREAS
SLUDGE & AREAS
CULTIVATED
SPRINKLER AREA
ELKLAND SEWAGE PLANT
DIKE
AREA
BACKWATER PROFILE EL. 1117
COWANESQUE
SLUDGE AREA
WATER EL. 1119.5
WATER EL. 1118.5
HLD. LGN.
RIVE
1132.1
1125
1130.5
1129.8
1121.4
1110.9
1128.0
1122.4
1120.5
1126.5
1127.0
1128.4
1126.0
1129.4
1123.7
1135.6
1136.2
1116.0
1130.6
1125.6
1137.0
1127.1
1135.5
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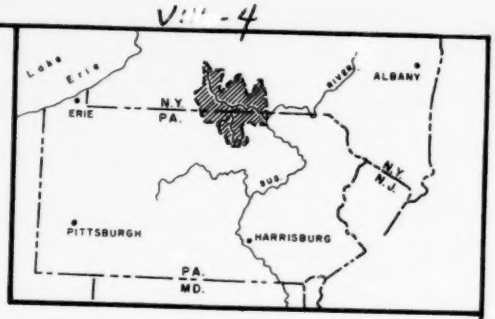
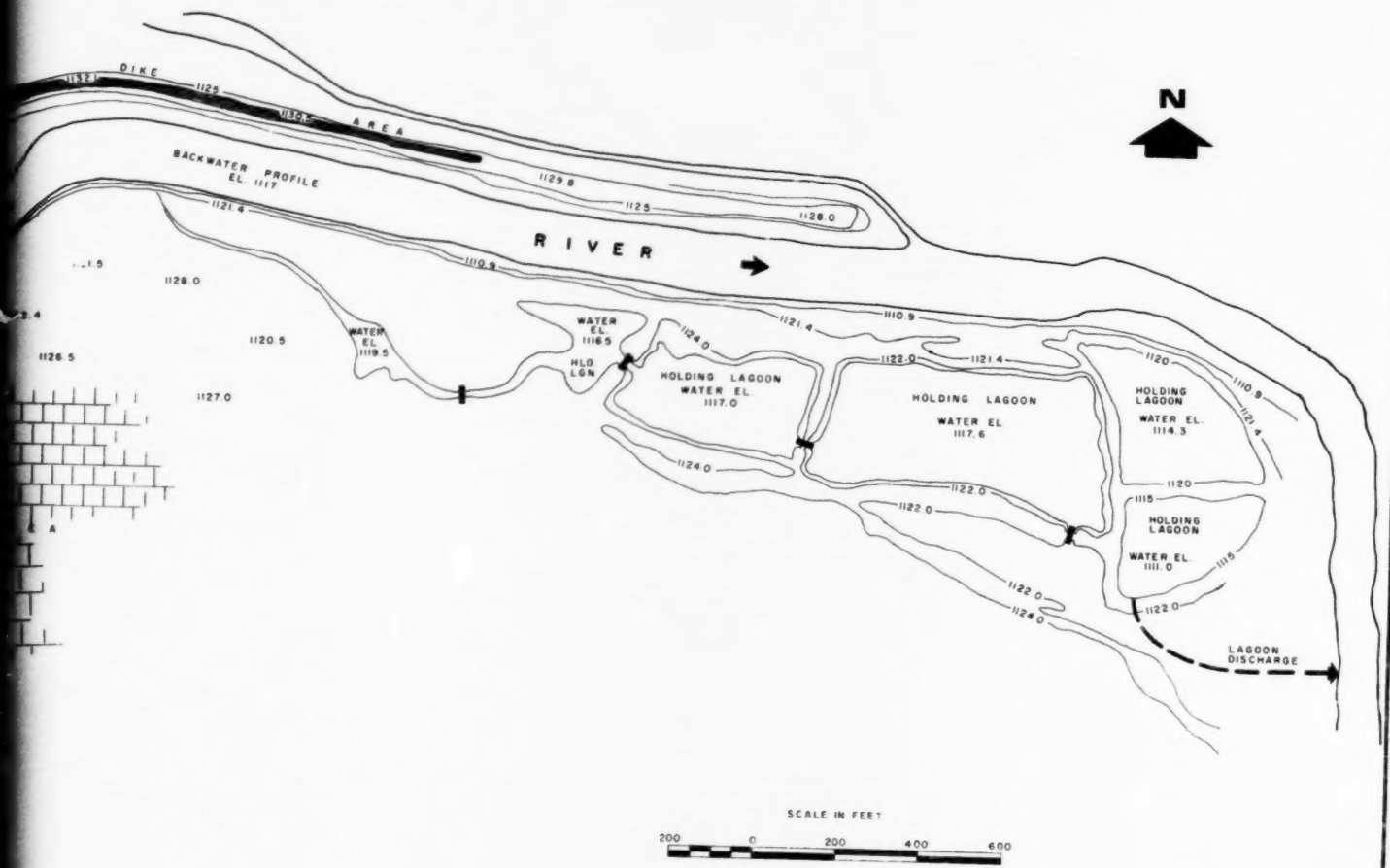


LOCATION MAP



SCALE IN FEET

200 0 200 400 600

WATER SUPPLY & WATER QUALITY CONTROL STUDY
CHEMUNG RIVER SUB-BASIN

ELKLAND LEATHER COMPANY WASTE TREATMENT FACILITIES

ELKLAND, PENNSYLVANIA

COWANESQUE RIVER

U. S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
MIDDLE ATLANTIC REGION CHARLOTTESVILLE, VA.

FIGURE 5

B

at the tanneries appears necessary prior to operation of the reservoir. In addition to potential degradation from organic wastes and color, nutrients in the tannery wastes may contribute to troublesome algal growths in the proposed reservoir, and surveillance measures appear warranted to ascertain if problems are developing so that corrective actions could be initiated.

The tannery at Elkland pumps sludge from the primary settling tanks to sludge drying beds across the River near the holding lagoons (see Figure 5). Although there is no discharge to the River from these drying beds, the possibility of inundation of these beds by the reservoir backwater and "washout" or "scour" during peak flood flows are a matter of concern in regard to the recreational use of the reservoir, particularly during subsequent summer periods. Scouring of the sludge beds could result in sludge settling out in the headwaters of the summer pool. Severe oxygen demands exerted during the more critical months of the summer could pose a threat to the fishery potential of the reservoir. In addition, scum accumulated or sludge deposited around the shore would detract from the recreational use of the reservoir.

Another item in the consideration of tannery wastes is the possibility that pathogenic bacteria from the hides of diseased cattle may survive the processing and waste treatment facilities. Considering that the hides are packed in salt when shipped to the tannery, and since very few pathogenic micro-organisms can survive desiccation[4], it does not seem likely that many types of pathogenic bacteria would survive.

At the tannery the hides are washed and then soaked in a strong alkaline solution (lime and sodium sulfide at a pH of about 12) for a period of three to seven days to loosen the hair. After screening by rotary screens, the waste water undergoes two-stage settling, providing approximately four more days of detention in which the wastes are still subjected to a high pH. According to the literature, pH in the range of 12 or more has provided complete destruction of Salmonella typhosa bacteria in municipal waste sludge.[5] In another investigation in which the research objective was to determine destruction of anthrax bacteria in wastes from a tannery employing lime and sodium sulfide processing, it was concluded "... no viable anthrax spore could be detected in either the effluent or

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[4] Water Quality Criteria, Committee Report, Federal Water Pollution Control Administration, U. S. Department of the Interior, April 1968.

[5] Doyle, Charles B., "Effectiveness of High pH for Destruction of Pathogens in Raw Sludge Filter Cake," Journal, Water Pollution Control Federation, Vol. 39, August 1967.

the sludge."[6] Anthrax spores are suspected to be more resistant to destruction than other pathogenic bacteria likely to be found on diseased animal hides; and since it appears from the above experiment that anthrax spores did not survive the processing facilities, it does not seem probable that survival of pathogenic bacteria in the waste water would be a serious consideration. The greatest concern from tannery wastes appears to be in the solids fraction in which bacteria such as the anthrax spore may be imbedded in animal or fatty tissue and partially protected from an environment conducive to their destruction.

The tannery at Elkland obtains excellent efficiencies in the removal of suspended solids, virtually 100 percent reduction, employing rotary fine-mesh screens. Hence, the liquid fraction would not pose the concern as would the sludge if pathogenic bacteria could survive the tannery processing facilities. The larger solids, such as hide scrapings, are disposed of at the tannery and are eliminated from the waste stream. Only the smaller particles passing the rotary screens remain in the waste flow. Since the sludge represents that portion of the tannery wastes containing the solids, it appears that measures to minimize potential inundation and washout of the sludge beds should be of greatest concern. However, in order to allay doubts as to the possible survival of pathogenic bacteria in the tannery sludge, a sampling program appears warranted prior to operation of the proposed reservoir.

The proposed reservoir spillway crest elevation is established at 1,117 feet, which means that the backwater flow profile created by the reservoir could extend upstream to the vicinity of the tannery as shown in Figure 5. Any elevation above 1,113 could produce backflow into the holding ponds, depending on level of the waste in the ponds at the time. Flooding of the lagoons to flow line elevation 1,117 would still retain the integrity of the lagoons and permit subsequent controlled releases upon subsidence of flood flows. The backwater curve at elevation 1,117 would not affect the sludge drying beds, as elevations of dikes around the beds vary between 1,122 and 1,126 feet. A more serious concern is the possibility of "washing out" the sludge beds during a major flood that produced out-of-bank flow some hours before the full flood control storage could be used.

During a field reconnaissance trip in October 1968, it was learned from local citizens residing near the tannery that the flood of March 1964 produced out-of-bank flow sufficient to encircle the

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[6] Gillissen, G., and Scholz, H. G., "A Large-Scale Procedure for Destroying Anthrax Spores in Effluents from Leather Factories," Arch. Hyg., Berl. 1961, 145, Bull. Hyg., Lond. 1962, 37, via Water Poll. Abs. 1962, 35, No. 9, 1839.

sludge beds, though it was not of such magnitude as to inundate or cause "scour" of the beds. The peak flow as measured by the Lawrenceville gage was reported to be 25,400 cfs March 5, 1964. Prior to 1964 the peak daily flows for which recorded flows are available (1951-1964) occurred in April 1961 (18,300 cfs), October 1955 (18,200 cfs), and January 1959 (18,100 cfs). Although the March 1964 is the largest flood of record, high water and storm data indicate that larger floods have occurred prior to installation of stream gages on the Cowanesque; viz., May-June 1889, March 1936, and May 1946.

The peak flood of March 5, 1964, based on a peak flow frequency analysis, has been estimated to have a six percent probability of occurrence in any year. This flow, as indicated previously, did not inundate or cause "scour" of the sludge beds. Therefore, the sludge beds would only be affected if a larger and less frequent flood than that of March 1964 were to occur.

The Borough of Elkland and the tannery are provided with a flood control dike. The dike is designed to control floods of 39,000 cfs, which is estimated to have a recurrence frequency of about once in 100 years. The elevation of the dike in the area of the tannery is about 1,137 to 1,130 feet and gradually decreases in the downstream direction, as shown in Figure 5. The dike provides about three feet of freeboard at the design flow of 39,000 cfs. On this basis, the peak crest of a 100-year flood could reach elevations of about 1,127 to 1,134 in the area of the sludge beds, resulting in overtopping of the dikes around the sludge beds. Thus a flood having a peak flow exceeding some flow between 25,400 cfs (which did not inundate the sludge beds in 1964) and 39,000 cfs (which would flood the beds) and a probability less than six percent and more than one percent in any year could result in inundation of the sludge beds and possible scour of the sludge.

In order to minimize potential scour of the sludge beds, several alternatives should be investigated: (1) provide a flood control levee along the right stream bank comparable to the existing levee on the left bank, (2) raise the dikes around the sludge beds, and (3) initiate a sludge management program to assure that the beds are empty during the high flow season.

The first alternative does not appear desirable since the construction of a dike on the right bank would constrict the flow in the stream channel and reduce the degree of flood protection for the Borough and tannery for which the levee was designed.

Raising the dike around the sludge beds should be explored further to determine its feasibility. This alternative would reduce the probability of flooding the sludge beds and would allow peak flood flows to pass around the beds without reducing the effectiveness of the flood control dike protecting the community on the left bank.

The sludge management program also appears worthy of further consideration. The industry in the past has allowed local residents to remove dried sludge for use as a fertilizer or soil conditioner. Establishment of a program to insure that the drying beds located in the flood plain would be emptied before high flow months would remove them as a threat to the recreational use of the reservoir. As a part of such a program, it appears possible that the sludge storage areas behind the levee on the left bank could be used during the period when the sludge beds in the flood plain were not available for use.

MINE DRAINAGE POLLUTION

A portion of the Tioga River drainage downstream from Blossburg, Pennsylvania, is influenced by coal mine drainage. Almost all of the mine drainage is contributed by three small tributaries: Morris Run, Coal Creek, and Bear Creek. This drainage severely degrades the quality of the Tioga River for 38 miles downstream to the confluence with Canisteo River.

Mine drainage originates in an isolated bituminous coal deposit which has been extensively mined both by deep and surface mining methods. Although abandoned deep mines contribute most of the mine drainage, abandoned surface mines add significantly to the problem by increasing the flow from the underground mines and by contributing directly to the mine drainage discharges. Acid loadings in the three streams draining the deposit vary from eight tons per day during low stream flow periods to 47 tons per day during high runoff periods.

Crooked Creek is not subject to mine drainage; and the water quality is suitable for the propagation of fish and aquatic life, as indicated by the operation of a trout fishery upstream from the proposed Hammond Reservoir site.

During periods of high runoff or flood conditions, the cross-over channel may be used to transfer water from the Tioga pool to the Hammond pool. Corps of Engineers' design information for the Tioga-Hammond project indicates that flows equal to and greater than a once-in-seven-year flood will result in overflows into the Hammond pool. The transfer of water from the Hammond pool to the Tioga pool is unlikely because of the relatively lower flood flows in Crooked Creek than in Tioga River. The Project is being designed on the basis of 128,600 cfs flood flow in the Tioga River and 53,900 cfs flood flow in Crooked Creek, with approximately the same storage below the level of the cross-over. Since the Tioga River and Crooked Creek Watersheds are contiguous, it is expected that flood flows would occur in proportion to the drainage area or the design flood flows so that the Tioga dam pool would be expected to fill to the cross-over sooner than the Hammond pool.

An analysis was made to determine the probable effects of overflows from Tioga Reservoir on water quality in Hammond Reservoir. Manganese appears to be the most sensitive indicator. Dry weather flows in Tioga River immediately upstream from the reservoir site have a manganese concentration of approximately 2 to 3 mg/l. This suggests similar concentrations in the Tioga Reservoir at normal pool elevations. Under flood or near-flood conditions, manganese concentrations would in all likelihood be reduced because of greater dilution by surface runoff.

As a basis for evaluation of the effects on the fishery in the Hammond pool, manganese concentrations of up to 3 mg/l were assumed in the spill-over into the Hammond pool. This concentration represents the most severe condition possible, but probably would not persist for long since the volume of flood water necessary to cause spill-over is expected to result in mixing and should result in sufficient dilution to reduce manganese concentrations below normal concentrations in the Tioga pool. Assuming that complete mixing would occur in the Hammond pool, resultant manganese concentrations would range from about 0.16 mg/l in the Hammond pool if the Hammond pool were initially at the level of the bottom of the spill-over channel to about 0.65 mg/l if the Hammond pool were initially at the level of the spillway crest. It is unlikely, however, that homogeneity in mixing will occur; rather, the manganese concentration would be higher near the spill-over point and in all likelihood considerable manganese would be discharged through reservoir releases during and after the flood, thus reducing the final concentration in the Hammond Reservoir.

The literature[7] suggests manganese concentrations of 1 mg/l or less are not deleterious to fish and aquatic life and indicates higher concentrations (dependent upon stream characteristics) have been tolerated for short periods of time. Accordingly, it is not expected that manganese concentrations resulting from infrequent spill-over from the Tioga Reservoir will adversely affect the fishery in the Hammond pool and particularly the trout fishery upstream in Crooked Creek.

Other constituents of mine drainage, such as iron and acidity, are not expected to cause adverse effects on the Hammond fishery. Iron, for example, is normally present in the Tioga River at the Project site, in concentrations of 0.1 to 2.4 mg/l, and 0.1 to 0.3 mg/l in Crooked Creek. Assuming that the maximum concentrations above existed during flood stages, the resultant concentrations in the Hammond pool would not be expected to exceed about 0.4 to 0.75 mg/l, respectively, for the spill-over conditions described above.

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[7] Water Quality Criteria, Publication No. 3-A, The Resources Agency of California, State Water Quality Control Board, Sacramento, California.

These concentrations are considered conservative, however, since dilution during flood stages would tend to reduce iron levels below the concentrations normally observed in low flows. The literature[7] indicates that waters throughout much of the United States contain concentrations of 0.7 mg/l and support a good fishery; hence, even under the maximum concentrations indicated above, iron is not expected to result in damaging concentrations in the Hammond Reservoir.

Acidity in the spill-over is expected to be reduced sufficiently by dilution so that, upon mixing with the alkaline waters of Hammond pool, the resultant mix would not be harmful to the fishery.

For the most severe condition, it was assumed that the spill-over from the Tioga pool contained acidity concentrations (110 mg/l as $CaCO_3$) and a pH (3.0) similar to data gathered during low flow conditions. When mixed with the alkaline waters of Crooked Creek (alkalinity of 15 mg/l as $CaCO_3$ and pH of about 7), the resultant concentration of the mix in the Hammond pool would be alkaline (approximately 4.3 mg/l as $CaCO_3$); which, according to work by Goldberg[8] is associated with a pH in the range of about 5.3 to 7.1. Therefore, based on the blending relationship and the most severe condition in the Tioga pool, it appears that overflow would not result in intolerable conditions in the Hammond pool. Any dilution that occurred would reduce acidity in the spill-over and result in further improved conditions in the Hammond pool.

WATER QUALITY STANDARDS

Increased use of water resulting from population growth combined with increased per capita use, expanding industrial requirements, and the mounting emphasis placed on recreational use of surface waters all contribute to the importance of maintaining water quality so as to permit maximum utilization of water resources. Water quality standards provide an objective basis for the planning of water resource programs so that water will be maintained at a quality suitable for anticipated beneficial uses.

Water quality standards considered necessary to maintain desired uses may be met by setting increasingly stringent limitations on concentrations and volumes of all waste effluents discharged to a stream or by limiting the concentration of waste in the stream itself by a combination of treatment and regulation of the flow in the stream.

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[7] See footnote on previous page.

[8] Unpublished laboratory results of acid-alkaline blending of stream flows.

In New York, the State Department of Health utilizes stream classifications and assigns quality standards to be maintained for each class. Classifications are established according to "best usage" which is defined as the usage requiring the highest level of quality considered to be in the best public interest for the intended areas. Table 10 lists the major tributaries of the Chemung Basin in New York and designates the assigned classifications.[9]

A minimum dissolved oxygen level of 4 mg/l for non-trout waters and of 5 mg/l for trout waters, and pH ranges between 6.5 and 8.5 have been established for Classes A, B, and C. For Class D, the minimum dissolved oxygen level is established at 3 mg/l, and pH ranges are established from 6.0 to 9.5. (Sewage or waste effluents must be effectively disinfected if they are to be discharged into Class A or B waters.)[10]

In addition, the State of New York has established standards for coliform organisms as follows:

Class A: Average coliform count not to exceed 5,000 MPN/100 ml in series of four or more samples collected during any 30-day period; an MPN exceeding 5,000/100 ml in not more than 20 percent of the samples collected during the period.

Class B: Average coliform count not to exceed 2,400 MPN/100 ml in a series of four or more samples collected during any 30-day period; an MPN exceeding 2,400/100 ml in not more than 20 percent of the samples collected during the period.

The Pennsylvania Department of Health has established water quality standards[11] and stream uses as given in Tables 11 and 12 for the portions of the Chemung, Tioga, and Cowanesque Rivers within the State.

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9 Official Classifications, Chemung River Drainage Basin, New York State Department of Health.

10 Rules and Classification and Standards of Quality and Purity for Waters of New York State, New York State Department of Health.

11 Water Quality Standards for Pennsylvania's Interstate Streams, Pennsylvania Department of Health, Harrisburg, Pennsylvania, June 1967.

TABLE 10

BEST USAGE AND ASSIGNED STREAM CLASSIFICATIONS
NEW YORK PORTION OF THE CHEMUNG RIVER BASIN

Stream	Classification	Best Usage
Tioga River	Class C	Warm-water fishery and other uses except bathing and water supply.
Cowanesque River	Class C	Warm-water fishery and other uses except bathing and water supply.
Canisteo River (all except as indicated below)	Class C	Warm-water fishery except short reaches of trout fishing above Hornell.
Canisteo River (headwaters and short reach at Hornell)	Class D	Agricultural or industrial cooling or process water supply and any other usages except for fishing, bathing, or as a source of water supply for drinking, culinary, or food processing purposes.
Cohocton River	Class C	Warm-water fishery in lower reaches, trout fishing upstream from Campbell.
	Class B	Bathing and recreation in reach near Village of Cohocton.
Chemung River (except as indicated below)	Class A	Water supply for drinking, culinary, or food processing purposes, and any other usages.
Chemung River (reach between Triburary 16 at Wellsburg to Tributary 29, Hoffman Creek, and reach upstream from Tributary 46)	Class C	Warm-water fishery and other uses except bathing.

TABLE 11

STREAM USE AND CRITERIA DESIGNATIONS
PENNSYLVANIA PORTION OF THE CHEMUNG RIVER BASIN

Stream	Water Use	Specific Criteria Group *
A. Tioga River (Source to Crooked Creek)	1.0 Aquatic Life 1.1 Cold-water fish	A
Cowanesque River (Source to Westfield)	2.0 Water Supply 2.1 Domestic 2.2 Industrial 2.3 Livestock 2.4 Wildlife 2.5 Irrigation 3.0 Recreation 3.2 Fishing 3.3 Water contact sports 3.4 Natural Area 4.0 Other 4.1 Power 4.3 Treated Waste Assimilation	A
B. Tioga River (Crooked Creek to Pennsylvania-New York State Line)	Same as streams under A except delete 1.1 and add: 1.2 warm water fish	B
Cowanesque River (Westfield to Pennsylvania-New York State Line)		B
C. Chemung River	Same as streams under B but with the additional uses of: 1.3 Migratory fish 3.1 Boating	B

* Specific Criteria Groups are defined in Table 12.

TABLE 12

PENNSYLVANIA SPECIFIC STREAM CRITERIA

Indicator	Group A	Group B
pH	Not less than 6.0; not to exceed 8.5	Not less than 6.0; not to exceed 8.5
Dissolved Oxygen	Minimum daily averages 6.0 mg/l; no value less than 5.0 mg/l	Minimum daily averages 5.0 mg/l; no value less than 4.0 mg/l
Iron	Total iron not to exceed 1.5 mg/l	Total iron not to exceed 1.5 mg/l
Temperature	Not to exceed 58° F or natural temperature, whichever is greater	Not to exceed 5° F rise above ambient temperature or a maximum of 87° F, whichever is less. Not to be changed by more than 2° F during any one-hour period.
Dissolved Solids	Not to exceed 500 mg/l as a monthly average value; not to exceed 750 mg/l at any time	Not to exceed 500 mg/l as a monthly average value; not to exceed 750 mg/l at any time
Bacteria	For the period 5/15-9/15 of any year not to exceed 1,000/100 ml as an arithmetic average value; not to exceed 1,000/100 ml in more than two consecutive samples; not to exceed 2,400/100 ml in more than one sample	For the period 5/15-9/15 of any year not to exceed 1,000/100 ml as an arithmetic average value; not to exceed 1,000/100 ml in more than two consecutive samples; not to exceed 2,400/100 ml in more than one sample

TABLE 12

PENNSYLVANIA SPECIFIC STREAM CRITERIA

Indicator	Group A	Group B
pH	Not less than 6.0; not to exceed 8.5	Not less than 6.0; not to exceed 8.5
Dissolved Oxygen	Minimum daily averages 6.0 mg/l; no value less than 5.0 mg/l	Minimum daily averages 5.0 mg/l; no value less than 4.0 mg/l
Iron	Total iron not to exceed 1.5 mg/l	Total iron not to exceed 1.5 mg/l
Temperature	Not to exceed 58° F or natural temperature, whichever is greater	Not to exceed 5° F rise above ambient temperature or a maximum of 87° F, whichever is less. Not to be changed by more than 2° F during any one-hour period.
Dissolved Solids	Not to exceed 500 mg/l as a monthly average value; not to exceed 750 mg/l at any time	Not to exceed 500 mg/l as a monthly average value; not to exceed 750 mg/l at any time
Bacteria	For the period 5/15-9/15 of any year not to exceed 1,000/100 ml as an arithmetic average value; not to exceed 1,000/100 ml in more than two consecutive samples; not to exceed 2,400/100 ml in more than one sample	For the period 5/15-9/15 of any year not to exceed 1,000/100 ml as an arithmetic average value; not to exceed 1,000/100 ml in more than two consecutive samples; not to exceed 2,400/100 ml in more than one sample

WATER POLLUTION CONTROL PROGRAMS

New York

With the establishment of the Pure Waters Program by the State of New York in 1965, the State has embarked on a mammoth pollution control program involving an expenditure of 1.7 billion dollars. Under the program, the State will finance comprehensive sewerage studies, assist in construction of new treatment plants, and allow tax benefits to industries for waste treatment plant expenditures. The comprehensive sewerage studies are essential prior to approval of a grant to aid the construction of adequate treatment facilities.

Under the Pure Waters Program, policy has been established that secondary treatment will be required where municipal waste treatment plants discharge into "Class C" waters or above, or where discharges into "Class D" waters result in an adverse effect on "Class C" waters or above.

Pennsylvania

The Pennsylvania State Legislature during 1966 passed a $500,000,000 bond issue which will provide $100,000,000 to the Pennsylvania Department of Health for sewage treatment construction grant purposes. In addition, $200,000,000 will be allocated to mine drainage abatement measures such as reclamation of areas disturbed by mining activities. The remaining $200,000,000 will be spent on construction and development of recreational areas.

The Pennsylvania Clean Streams Act, which became effective in January 1966, is another step toward improvement of water quality in areas affected by mine drainage. The Act prohibits discharge of acid waters or other polluting discharge from active coal mines.

The Pennsylvania Department of Health in the past has stipulated the degree of waste treatment required for specific streams based on existing stream quality. With the establishment of water quality standards, the Department of Health initiated action to require a minimum of secondary treatment (85 percent BOD removal) for biodegradable wastes before discharge to streams not degraded by mine drainage. For streams significantly degraded by mine drainage, the State previously did not require treatment of sewage unless degradation attributable to organic waste discharges was evident. The State now requires a minimum of primary treatment prior to discharge to streams receiving coal mine drainage to the extent that all alkalinity of the stream is exhausted and the pH of the stream is usually 4.0 or less at the point of discharge or througnout the stream. However, if the quality of the water in the receiving stream is expected to improve significantly because of scheduled mine drainage

abatement measures, or if the primary treated effluent would adversely affect downstream waters, a minimum of secondary treatment shall be required.

FLOW REGULATION

Present water quality and stream uses were evaluated for the Chemung River Basin, and it was determined that dissolved oxygen and coliform bacteria were generally the most critical quality standards to be maintained to protect present and future uses of the streams. However, in the Tioga River where mine drainage is the primary pollutant affecting quality, pH (or acidity), iron, and manganese concentrations were the main indicators of concern.

The coliform bacteria can be controlled by adequate disinfection of wastes prior to discharge; however, to maintain the DO standard, treatment in excess of secondary treatment (85 percent BOD removal) and/or flow regulation will be necessary for the water service areas of Hornell on the Canisteo River and Corning and Elmira on the Chemung River.

Organic Wastes

In the Tioga and Chemung Rivers the primary uses to be preserved are: water supply, fish and aquatic life, and recreation. Periods of degraded water quality adversely affect many uses of the stream, resulting in restriction or cessation of beneficial uses. While recreation and water supply uses could be restricted during short periods of low water quality, fish and aquatic life usually sustain severe damage from adverse stream conditions. Biological characteristics of a stream reflect long-term or residual effects from even short periods of low water quality. Other uses are adversely affected only during periods of poor quality and generally do not suffer residual effects.

The proposed Tioga-Hammond and Cowanesque Reservoir Projects are located upstream from the water service areas of Corning and Elmira and could provide flow regulation to the reaches of the Chemung River affected by discharges from these areas. Flow regulation by piping of flows from the Tioga-Hammond and Cowanesque Reservoirs to the Canisteo River to protect stream quality downstream from Hornell does not appear practical because of the distance and topography involved. Possible alternative control measures to enhance and protect water quality in the Canisteo River include advanced waste treatment by Hornell and/or flow regulation from the Corps of Engineers' potential reservoir site #100 located on Bennett Creek (a tributary

discharging to the Canisteo River about six miles downstream from Hornell). Hence, for the purposes of this report, the contribution of flow regulation provided by the Tioga-Hammond and Cowanesque Reservoirs was based on water quality control in the Chemung River downstream from the Corning-Elmira water service areas. Based on the Streeter-Phelps formulation of the oxygen sag curve, the water quality control requirements for assimilating present and anticipated waste loads while maintaining an average monthly dissolved oxygen level of 5.0 mg/l (considered comparable to a minimum daily level of 4.0 mg/l) during low stream flow conditions are presented in Table 13 for treatment efficiencies of 85, 90, and 95 percent BOD removal.

Hydrological data were analyzed to evaluate the adequacy of various reservoir sizes at the proposed Tioga-Hammond and Cowanesque sites to meet the downstream flow requirements as presented in Table 13. Stream flow data for a 500-year period were synthesized from historical data by the Fiering-Pisano model and utilized in the analysis. These flows were routed through reservoirs of various sizes to determine the storage volumes needed to meet the water quality control flow requirements of Table 14.

From the analyses, it is estimated that 66,500 acre-feet will be needed by year 2020 to meet the flow requirements after secondary treatment (85 percent BOD removal). Storage volumes needed if additional treatment is provided are presented in Table 14.

The storage requirements are based on meeting the stream flow requirements throughout 98 percent of the years, a probability which is considered comparable to the protection level associated with the seven-day, 50-year flow criteria established under the Water Quality Standards of the State of New York.

The previous storage analyses are based on stream flow being utilized to satisfy all of Elmira's water supply needs except for the 10.7 mgd presently obtained from ground water. The water supply withdrawals would reduce the natural stream flow available for water quality control. If the ground water were utilized to satisfy all water supply needs at Elmira, thereby permitting the use of the entire stream flow for water quality control, the required storages for water quality control providing a 98 percent protection level would be as listed in Table 15.

It is expected, however, that some combination of surface and ground water usage will occur. To facilitate the estimation of water quality control storage needed if a combination of surface and ground water were used, Figures 6 and 7 present reservoir storage for maintaining quality standards plotted against water supply withdrawals from the Chemung River at Elmira.

TABLE 13

FLOW REQUIREMENTS TO MAINTAIN
5.0 mg/l AVERAGE DO OBJECTIVE IN THE CHEMUNG RIVER
DOWNSTREAM FROM CORNING-ELMIRA WATER SERVICE AREAS

Year	Treatment Level, % BOD Removal	Flow Requirements in cfs*											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1980	85	65	65	65	65	90	164	176	176	133	92	65	65
	90	65	65	65	65	65	108	116	116	89	65	65	65
	95	65	65	65	65	65	65	65	65	65	65	65	65
2000	85	113	113	113	113	172	310	334	334	252	174	113	113
	90	113	113	113	113	119	207	221	221	169	120	113	113
	95	113	113	113	113	113	117	118	118	114	113	113	113
2020	85	197	197	197	197	270	502	538	538	405	282	204	197
	90	197	197	197	197	197	335	360	360	276	200	197	197
	95	197	197	197	197	197	208	212	212	200	198	197	197

* The tabulated flow requirements include organic waste flow volumes returned to the stream from the Elmira water service area.

TABLE 14

STORAGE REQUIREMENTS AT TIOGA-HAMMOND AND COWANESQUE RESERVOIRS TO MEET PROJECTED FLOW REQUIREMENTS IN THE CHEMUNG RIVER DOWNSTREAM FROM CORNING-ELMIRA WATER SERVICE AREAS

Year	Treatment Level	Storage Requirements (Acre-Feet)
1980	85	14,250
	90	5,100
	95	0
2000	85	36,800
	90	14,800
	95	0
2020	85	66,500
	90	27,000
	95	0

TABLE 15

STORAGE REQUIREMENTS AT TIOGA-HAMMOND AND COWANESQUE RESERVOIRS TO MEET PROJECTED FLOW REQUIREMENTS IN THE CHEMUNG RIVER DOWNSTREAM FROM CORNING-ELMIRA WATER SERVICE AREAS (Ground Water Used to Satisfy All Water Supply Needs at Elmira)

Year	Treatment Level	Storage Requirements (Acre-Feet)
1980	85	4,200
	90	0
	95	0
2000	85	17,200
	90	3,200
	95	0
2020	85	38,800
	90	9,500
	95	0

Mine Drainage

The Tioga River from Blossburg, Pennsylvania, to the Canisteo River confluence in New York (a distance of about 38 miles) is

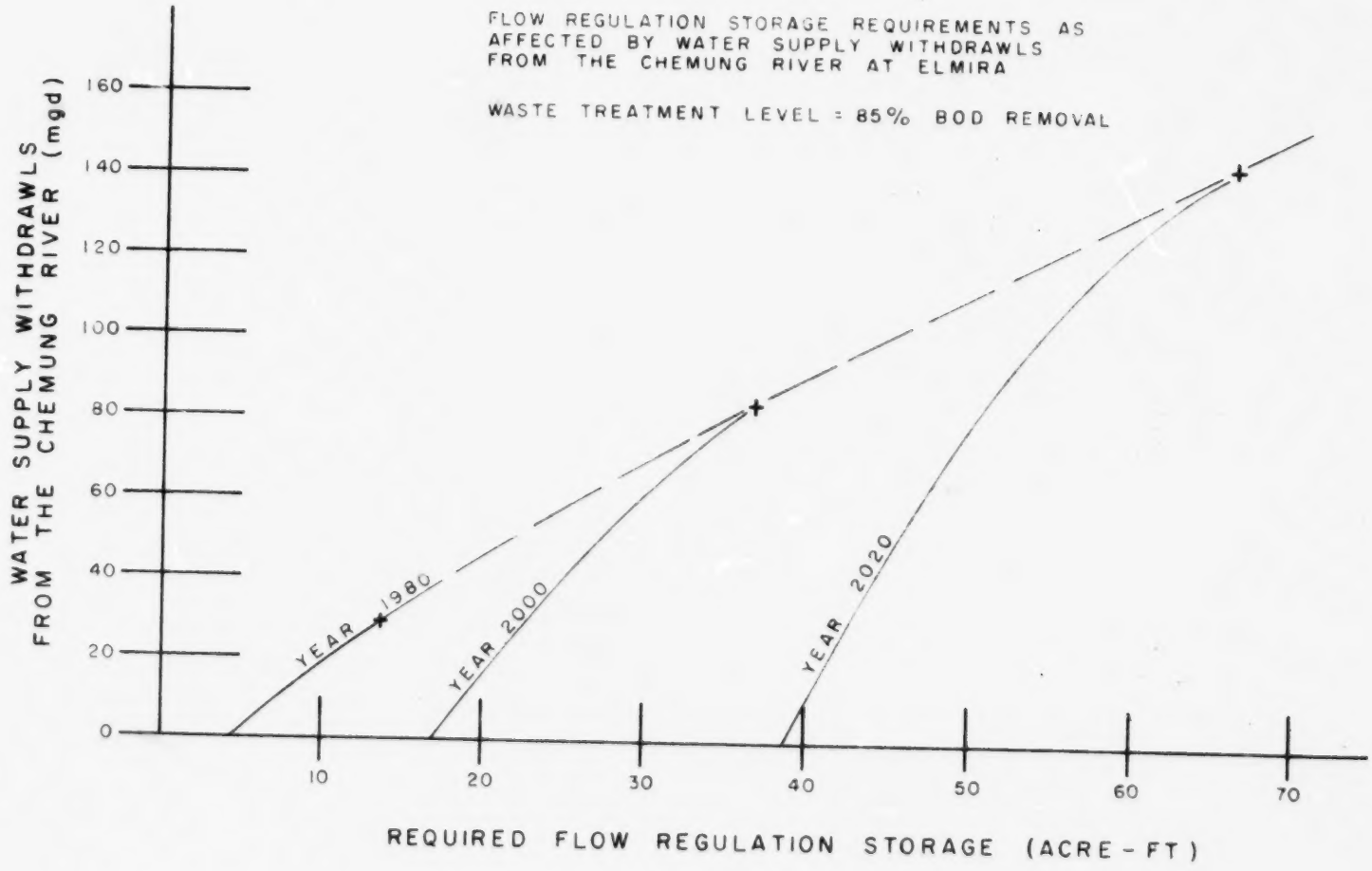
FLOW REGULATION STORAGE REQUIREMENTS AS
AFFECTED BY WATER SUPPLY WITHDRAWLS
FROM THE CHEMUNG RIVER AT ELMIRA
WASTE TREATMENT LEVEL = 85% BOD REMOVAL
WATER SUPPLY WITHDRAWLS
FROM THE CHEMUNG RIVER (mgd)
160
140
120
100
80
60
40
20
0
YEAR 1980
YEAR 2000
YEAR 2020
10
20
30
40
50
60
70
REQUIRED FLOW REGULATION STORAGE (ACRE-FT)

FIGURE 6

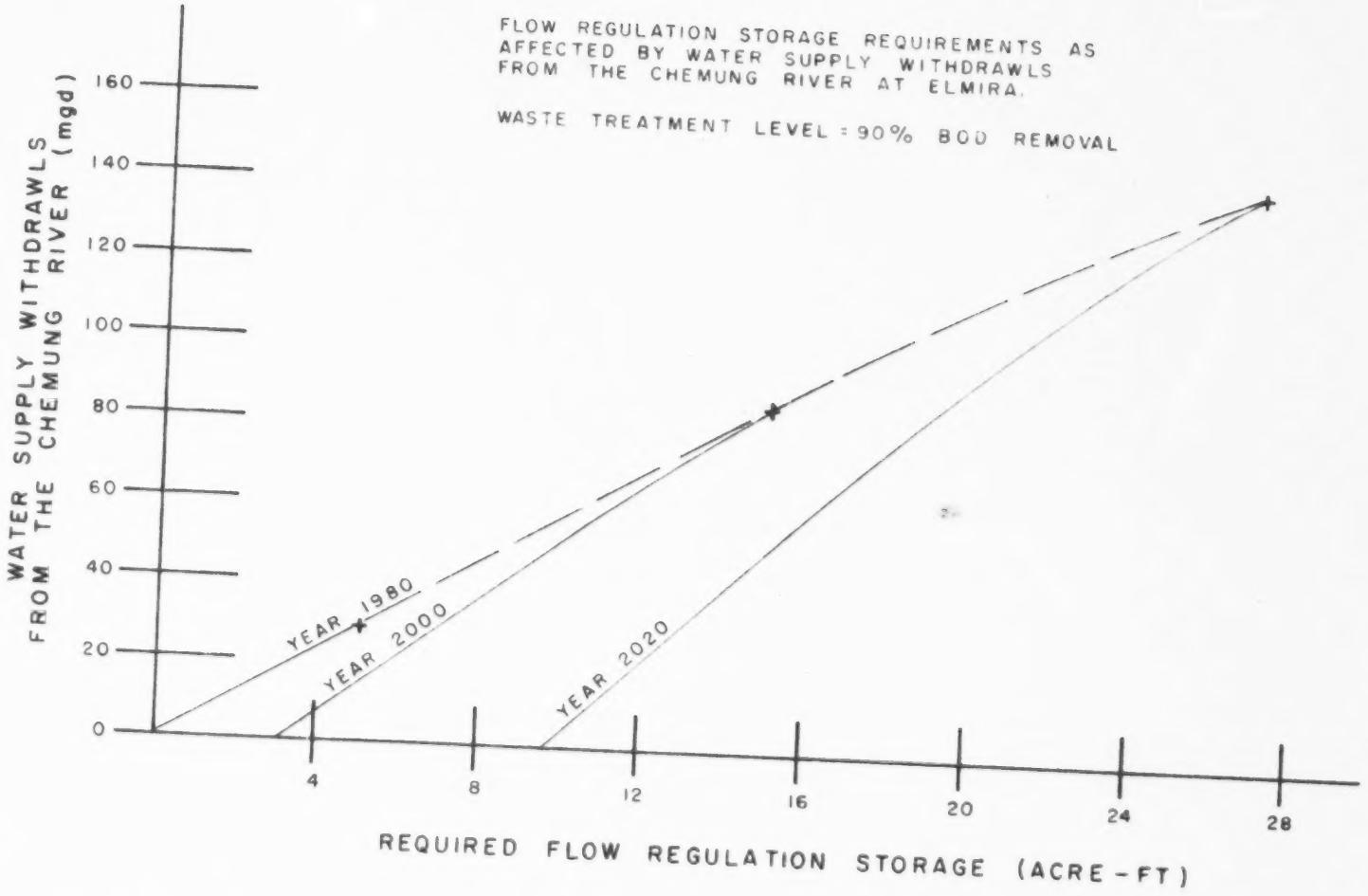
FLOW REGULATION STORAGE REQUIREMENTS AS AFFECTED BY WATER SUPPLY WITHDRAWLS FROM THE CHEMUNG RIVER AT ELMIRA.
WASTE TREATMENT LEVEL = 90% BOD REMOVAL
WATER SUPPLY WITHDRAWLS FROM THE CHEMUNG RIVER (mgd)
160
140
120
100
80
60
40
20
0
YEAR 1980
YEAR 2000
YEAR 2020
4
8
12
16
20
24
28
REQUIRED FLOW REGULATION STORAGE (ACRE-FT)

FIGURE 7

adversely affected by mine drainage to the extent that fish and aquatic life are virtually eliminated; recreation is inhibited; and the water is unsuitable for water supply without extensive treatment. Mine drainage abatement measures and/or control of releases from the Hammond and Cowanesque Reservoirs in proportion to releases from the Tioga Reservoir appear to be the most effective control actions available to preserve these beneficial uses in at least the lower portion of the stream.

An evaluation was made to determine the potential of flow regulation to control acidity levels downstream from the proposed Tioga and Hammond Reservoirs. Five alternative reservoir operating and acidity control conditions were analyzed. These are:

1. No reservoirs present, and
2. Both reservoirs in place and operating according to proposed pool levels; i.e.,

Tioga winter pool	2,200 acre-feet
Tioga summer pool	11,710 acre-feet
Hammond winter pool	2,800 acre-feet
Hammond summer pool	8,210 acre-feet

These above alternatives assume no acid abatement measures are undertaken in the upper Tioga River Basin. For case 2, the reservoir would be raised from the winter pool level during April and May to provide the summer pool by June 1. Between September and October, the summer pool would be lowered to the winter pool level.

3. The Hammond pool operated for water quality control only, no mine drainage abatement measures undertaken in the upper Tioga River watershed;
4. The Hammond pool operated for water quality control only, mine drainage measures undertaken affording about 21 percent reduction in acid loadings to the Tioga River; and
5. The Hammond pool operated for water quality control only, mine drainage measures undertaken affording 50 percent reduction in acid loadings to the Tioga River.

For alternatives 3 through 5, the Tioga pool was operated as in case 2 above, except that the Hammond pool was allowed to fill to 60,000 acre-feet before releases were made.

A regression analysis was made of sampling data to relate flow with alkalinity in Crooked Creek and acidity in Tioga River. Using these regression relationships, 12.5 years of historical daily

flow records were analyzed to estimate the daily alkalinity (negative if acid) of the inflow to each pool and the total alkalinity in each pool. In each case the objective in controlling the releases was to maintain a downstream alkalinity concentration of 10 mg/l or more--the concentration considered necessary for meeting a minimum pH of 6.5 established as part of the water quality standards.

The results of the evaluation are summarized in Table 16. The results indicate that for cases 1 and 2, an alkalinity of 10 mg/l downstream from the reservoir could be maintained only for about six percent of the time. However, for cases 3 through 5, the objective could be met for about 61 percent to 91 percent of the time. Operation of the Hammond pool for water quality control only would preclude multi-purpose uses such as flood control and recreation for which the project is also designed. Hence, from the above evaluation, it appears that controlled releases from the Hammond Reservoir on Crooked Creek cannot provide sufficient alkalinity to neutralize Tioga River flows to continuously maintain water quality standards considered necessary to protect the fishery or to provide recreational and other desired water uses downstream from the proposed Tioga-Hammond Reservoirs.

TABLE 16

TIOGA RIVER - CROOKED CREEK
FLOW REGULATION
ALKALINITY CONTROL

Condition		Percent of Time Alkalinity 10 mg/l or more maintained downstream from the reservoirs
I.	Operation of reservoirs to maintain proposed winter and summer pools	
Case 1	No reservoirs	6.0
Case 2	Both reservoirs in place:	
	Fill from May 1 to June 1	6.1
	Fill from April 1 to June 1	6.0
II.	Operation of Hammond Pool for flow regulation only	
Case 3	No mine drainage abatement	61
Case 4	21 percent reduction mine drainage	79
Case 5	50 percent reduction mine drainage	91

Releases from the Cowanesque Reservoir could provide the additional alkalinity needed to protect water uses in the six-mile reach of the Tioga River from the Cowanesque River to the Canisteo River; however, the seven-mile reach between the Tioga-Hammond Reservoir and Cowanesque confluence would not benefit from the releases unless flow from the Cowanesque Reservoir were pumped to the Tioga-Hammond dam site.

MINE DRAINAGE ABATEMENT MEASURES

An alternative, and perhaps a more practical solution to the mine drainage problems, might be abatement measures in the headwater mining areas. Abatement measures, if effective, would enhance water quality in the reaches upstream from the Tioga Reservoir and the Tioga pool itself, as well as the stream reaches that would be regulated by the above reservoirs. Water quality would be improved throughout the 38-mile reach presently degraded by mine drainage, rather than the 13 miles which might be improved by flow regulation. Also, if the water impounded in the Tioga pool were not degraded by mine drainage, additional uses such as recreation and fishing could be enjoyed in the reservoir. Furthermore, elimination of acid conditions in the waters impounded by the Tioga Dam would permit redesign in the Tioga-Hammond structures, with attendant savings in construction costs.

Mine drainage to the Tioga River originates primarily in the Morris Run Watershed from inactive deep mines and both active and inactive strip mines. A recent study conducted by a consulting engineering firm under contract to FWPCA indicated that 41 strip mines in the Morris Run Study Area, 39 of which were inactive, contributed impounded waters to deep mine workings either through direct connections or by infiltration. Five inactive strip mines discharged mine drainage intermittently to surface streams as the result of accumulation of precipitation. The study disclosed 72 major deep mine entries in the study area, nine of which discharged acid drainage to surface streams. In addition, the study disclosed four separate stretches of stream bed and three major subsidence areas where surface waters infiltrate underlying deep mine workings.

For the Morris Run Study Area, seven abatement measures (six preventive and one treatment measure) were determined to be applicable in light of Study Area problems and conditions.

Abatement measures considered applicable, either alone or in combination, are:

Preventive Measures

Reconstruction of Stream Channels
Construction of Surface Water Diversion Ditches
Restoration of Strip Mines
Filling of Strip Mines
Restoration of Subsidence Areas
Sealing of Ground Surfaces

Treatment Measures

Neutralization and Oxidation of Acid Waters

Four abatement plans consisting of various combinations of applicable preventive and treatment measures were considered for detailed study. The anticipated results and the cost of the plan recommended in the study report are summarized as follows:

		Estimated Abatement Costs		
			Average Annual Cost (Millions)	
Abatement Measure(s)	Estimated Reduction	First Cost (Millions)	Average Over Initial 30 Years	Average Over 300 Years
Preventive	Volume - 21% Iron Tonnage - 21% Acid Tonnage - 23%	3.75	0.240	0.035
Treatment	All mine drainage remaining after construction of preventive measures	3.02	0.501	0.420
Total Abatement Costs		6.77	0.741	0.455

The above plan was recommended on the basis of initial and long-term costs and flexibility which would permit application of preventive measures as construction funds become available.

The recommended mine drainage abatement plan would enhance quality in the Tioga River in the 38-mile reach presently degraded by mine drainage and would provide water quality suitable for recreation in the impoundment itself. Tangible benefits could be claimed by mine drainage abatement measures which would provide water suitable for recreational, fishery, and agricultural uses. Benefits attributable to mine drainage abatement measures would also result from a

reduction in costs of construction, operation, and maintenance of the Tioga-Hammond Dam if provided in time that construction could be modified. With the elimination of acid waters in the Tioga River, a single dam could be constructed so that Tioga and Hammond pools could be operated as a single reservoir. This modification would eliminate the control works in the cross-over channel now proposed between the two pools and would eliminate one of the two proposed operating towers. The estimated tangible average annual benefits are summarized in Table 17.

As reported previously, the average annual cost of the abatement plan to eliminate mine drainage from the Tioga River ranged from $707,000 to $455,000 for amortization periods of 30 years and 300 years, respectively. Although the estimated tangible benefits ($303,000) are less than the cost of the abatement measures, the total benefits could be substantially greater if representative values could be assigned to: (1) the reduction of damages associated with erosion and corrosion of concrete and metal structures, (2) the increased value of reclaimed mining areas and property adjacent to acid degraded streams, and (3) greater potential for economic growth and development in this area.

Mine drainage pollution is one of the most severe problems in Pennsylvania. More than 2,000 miles of streams are adversely affected by acid alone or by acid in combination with other constituents of mine drainage. Hence, the scope of the problem is widespread and clearly points to the need for abatement action. Implementation of the mine drainage abatement plan for the Tioga River watershed would serve to verify the cost and effectiveness of the abatement measures. In addition to yielding benefits to the Tioga River reaches, the Tioga River abatement program could serve as a model for implementing similar actions in other mine drainage problem areas.

TABLE 17

ESTIMATED TANGIBLE BENEFITS
TO MINE DRAINAGE ABATEMENT[1]

TIOGA RIVER WATERSHED

Type Water Body	Affecred Reach Miles	Affecred Reach Acres	Rec. & Aesthetics An. Use Days	Rec. & Aesthetics Av. An. Benefits	Fishing An. Use Days	Fishing Av. An. Benefits	Agric. Av. An. Benefits	Reduced Cost of Construction and Operation of Tioga-Hammond Dam Av. An Benefits
Stream	38	297	16,800	$33,500	3,600	$7,200	$29,500	---
Tioga-Hammond Lake	--	570	176,200[2]	176,200[2]	10,000	10,000	---	---
Totals	38	867	193,000	209,700	13,600	17,200	29,500	$46,800

GRAND TOTAL $303,200

[1] Estimates based on evaluations by the Mine Drainage Work Group, Susquehanna River Basin Comprehensive Water Resource Study.

[2] Estimates of benefits for recreational usage attributable to mine drainage abatement may be high since usage such as boating and non-contact forms of recreation could exist with the acid conditions prevailing.

IX. BENEFITS

WATER SUPPLY

Only one water service area, Elmira, will have water supply deficiencies which could be satisfied practicably by storage in the proposed Tioga-Hammond-Cowanesque Reservoirs. The remaining communities expected to have water supply deficiencies are remote from the regulated reaches of the Tioga and Chemung Rivers and are located in areas where alternative sources are available for development at lesser cost to meet the projected needs. Therefore, it is not expected that provision of storage in the proposed reservoirs would be of benefit to water users outside the Elmira area.

For Elmira, water supply benefits were evaluated in terms of the cost of the water supply most likely to be developed by the community. Alternative water supply sources considered were: (1) development of groundwater, and (2) provision of a single-purpose water supply reservoir. Because of the large glacial aquifers underlying the Elmira area, groundwater development was initially proposed as an alternative to a water supply reservoir. However, development to continuously meet Elmira's future needs of about 172 mgd would require an elaborate series of wells and provisions to artificially recharge the aquifer. Preliminary cost estimates of the potential groundwater supply system indicated the costs could conceivably amount to twice that of reservoir development. However, the cost data used in assessing the well system were preliminary in nature and, further investigation and analyses would be necessary before a more reliable estimate of the cost of this alternative could be made. For this reason, and because of the uncertainties at this time as to the feasibility of development and operation of a well system of this scale, groundwater development was considered a more costly alternative than surface for the purposes of this report in the determination of benefits.

The benefits of an adequate water supply to the City of Elmira are the total of the tangible and intangible contributions of water supply to the satisfaction of human needs and desires, but are not fully measurable in monetary terms. The evaluation of the expansion benefits that would be foregone in Elmira if an adequate water supply were not available or were not provided in a timely fashion is highly subjective. Therefore, it was assumed that the benefits attributable to water supply storage would be at least equal to the least costly means of supply needs.

For purposes of estimating benefits for development of a water supply system for meeting Elmira's needs through year 2020, tentative cost estimates of providing a water supply reservoir were employed. These costs are presented in Table 18 for the two following conditions:

TABLE 18

RESERVOIR STORAGE FOR WATER SUPPLY

Alternative	Date of Need (year)	Total Water Supply Need (mgd)	Storage Required * (ac-ft)	Constr. Date (year)	Initial Cost	Annual Operation and Maintenance Costs	Average Annual Cost 1980-2080
Industrial Cooling Water Included							
I-a. Reservoir Storage	1980	56	2,700				
	2000	108	12,700				
	2020	172	37,000	1980	$12,580,000	$21,700	$609,900
Industrial Cooling Water Excluded							
I-b. Reservoir Storage	1980	41	0				
	2000	95	9,250				
	2020	154	29,500	1980	$10,030,000	$17,300	$486,290

* Storage volume of single purpose reservoir to meet only water supply needs.

(1) industrial cooling water needs would be met on a once-through basis, and (2) heat dissipation needs would be met by cooling towers and make-up needs were assumed to be negligible. The evaluation was based on construction of the reservoir in 1980, since small deficiencies would be expected around 1980 and would become more severe throughout the period to year 2020. Additional use of groundwater could delay the need for construction of the reservoir. However, this alternative would involve an analysis to determine the optimum conjunctive use of reservoirs and groundwater development and, as stated previously, the groundwater cost information appears to be too preliminary at this time to assess groundwater development with a reasonable degree of certainty.

Based on the premise of a water supply reservoir constructed in 1980 to satisfy Elmira's needs through year 2020, the initial costs as given in Table 18 are expected to be approximately $12,580,000 or $10,030,000, respectively, for industrial cooling water needs being met by storage or by cooling towers. Amortized over a 100-year period from 1980 to 2080 at 4 5/8 percent interest plus operation and maintenance charges, the annual value of water supply benefits would be approximately $610,000 or $486,000 for the above two conditions, respectively.

WATER QUALITY

The benefits stemming from provision for flow regulation or other alternative means for maintaining water quality standards may be appraised as the increased value of goods and/or services resulting if quality is controlled, as compared with their value in the absence of these measures. The benefits from maintaining water quality include increased economic activity, increased or improved recreational opportunities, reduced municipal and industrial water treatment costs, increased industrial production, improved health and welfare, greater availability of fish and other aquatic life, and enhanced aesthetics of the aquatic environment.

The significant damages that would result in the Chemung River Basin in the absence of water quality control measures are loss of recreational opportunity, damage to fish and wildlife, and degradation of aesthetics.

Increased recreational use in the 45-mile reach downstream from Corning and Elmira appears to be one of the most significant potential benefits for which monetary values could be estimated for resultant water quality control measures. At present, most of the water-oriented activities are limited by degraded quality. Estimates by the U. S. Bureau of Outdoor Recreation indicate a

potential recreational use of 109,000 annual user-days throughout the 45-mile reach having a value of $109,000 annually.

Increased sport fishing also represents a significant potential benefit to be derived from stream quality improvement measures. At present, most of the fishing effort in the study area is confined to upper stream reaches and tributary headwaters. The value of the fishery for the Chemung River in the 45-mile reach was evaluated by the U. S. Bureau of Sport Fisheries and Wildlife. The average annual use of 28,400 fisherman days for sport fishing was estimated to have a value of $56,800 annually.

It has not been ascertained at this time whether fishing and recreation benefits justify storage and controlled flows in the Chemung River. Sufficient data are not available to directly evaluate the economic value of all of the effects of water quality improvement; however, the approved water quality standards indicate the quality and uses desired in the Chemung River. The cost of achieving this quality should be a reasonable estimate of the benefits obtained. In all likelihood the benefits would considerably exceed this cost if monetary values could adequately be assigned to all potential benefits, tangible and intangible.

For the area of this study, the two water quality improvement alternatives considered to have the greatest potential application are flow regulation and advanced waste treatment. Estimated costs are summarized in Table 19 for the two alternative conditions presented in Chapter VIII: (1) surface water utilized for meeting both the water supply needs and water quality needs, and (2) surface water utilized only for meeting the water quality needs.

Various methods of advanced waste treatment have been developed for removal of very high percentages of pollutants from waste flows. These methods are now being demonstrated in laboratory and pilot scale plant applications. One method, the carbon adsorption process, has been proven effective in full scale operation and was used in the present evaluation. Carbon adsorption units are usually preceded by conventional secondary treatment, followed by lime alum coagulation-sedimentation and sand filtration. Treatment efficiencies using these processes may be expected to achieve as high as 99 percent BOD removal.[12]

The water quality evaluations indicated that operation of the advanced waste treatment facilities would be needed only during

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[12] Stephan, David G., "Water Renovation - Some Advanced Treatment Processes," Civil Engineering, Volume 35, September 1965.

TABLE 19

COMPARISON OF WATER QUALITY MANAGEMENT ALTERNATIVES

Alternative	Treatment Level % BOD Reduction	Storage Required[1] (acre-feet)	Storage Costs		Advanced Waste Treatment Costs		Average Annual Cost (1980-2080)
			Construction 1980	Average Annual Operation and Maintenance	Construction PW 1980[2]	Average Annual Operation and Maintenance	
I. Surface water provided for both water supply and water quality needs.	85%	66,500	$23,940,000	$41,100	---	---	$1,160,500
	90%[3]	27,000	9,720,000	16,600	$2,435,920	$140,690	725,700
	95%[4]	0	0	0	8,596,770	325,580	727,600
II. Ground water provided for water supply needs and surface water provided for water quality	85%	38,800	13,968,000	23,900	---	---	677,000
	90%[3]	9,500	3,420,000	5,700	2,435,900	140,690	420,200
	95%[5]	0	0	0	5,448,500	238,270	493,000

[1] Storage for water quality management: For Alternative I, it is storage needed in addition to water supply storage presented in Table 18. For Alternative II, water supply storage is not needed.

[2] Basic facilities provided in 1980 and expanded to meet needs through 2020.

[3] 90% AWT - Coagulation and sedimentation from 1980 to 2080.

[4] 95% AWT - Coagulation and sedimentation and carbon adsorption from 1980 to 2080.

[5] 95% AWT - Coagulation and sedimentation from 1980 to 2000 and coagulation and sedimentation and carbon adsorption from 2000 to 2080.

the critical period extending from June through September. Therefore, operating costs included in Table 19 represent operations during four months of each year. During other months of the year, secondary treatment and the available streamflows, as indicated in historical flow records, are adequate to maintain water quality at or above standards.

Calculations presented in Table 19 indicate that the combination of reservoir storage and advanced waste treatment providing 90 percent BOD removal is the least costly alternative for maintaining water quality whether surface water or groundwater is utilized to meet water supply needs. However, as pointed out previously, reliance upon groundwater alone to meet Elmira's future water supply needs is not favored at this time because of the uncertainties both in economics and feasibility of development. The evaluation of groundwater usage as related to water quality management is presented here to demonstrate that water quality control costs depend upon other water resource development decisions and could conceivably be lower if groundwater development were found to be technically feasible and were adopted. Another complication with the well system would be the drawdown of the aquifer which could reduce stream flows during critical periods if the wells were located near the stream.

Based on the conclusion that surface water will be utilized to meet longer term future water supply and water quality control requirements, the least costly alternative for water quality management and providing suitable quality for the intended stream uses is reservoir storage of 27,000 acre-feet in combination with advanced waste treatment of collectable wastes, resulting in an overall removal of 90 percent of the BOD reaching the Chemung River. As shown in Table 19, this alternative may be expected to cost approximately $725,700 annually (in addition to an adequate level of secondary treatment) including amortization over a 100-year period at 4 5/8 percent interest and operation and maintenance charges. The cost of this alternative is taken as a measure of the value of the benefits attributable to streamflow regulation under the assumption that the benefits are at least worth the cost of meeting the water quality standards established to protect present and anticipated stream uses. Hence, for the purposes of this study, the average annual value of benefits, resulting from reservoir storage of 66,500 acre-feet (as given in Table 19) for flow regulation purposes, is estimated at $725,700.

It has not been ascertained at this time what portion of the water quality management storage and controlled flows in the Chemung River could be justified directly for fishery and recreational use; however, control of flows made possible for reservoir storage as presented in Table 19 would protect these uses and meet

water quality standards. The fishery and recreational benefits together are estimated at $165,800 annually; therefore, of the $725,700 benefits which may be attributable to the maintenance of water quality by streamflow regulation, $165,800 are expected to accrue from fishery and recreational uses downstream from the Corning and Elmira service areas. If representative values for all of the benefits, both tangible and intangible, could be realistically estimated, the total would be expected to exceed the $725,700 value.

It is expected that intangible benefits would be greater for flow regulation than for advanced waste treatment. Although advanced waste treatment would achieve water quality standards and protect the intended uses, flow regulation would contribute to a larger conservation pool (with attendant increases in reservoir fishery and recreational benefits), increased streamflow (with greater opportunity for in-stream uses), greater control of natural pollution, and the assurance of sustained streamflow throughout the year.

The benefits to be derived from water quality improvement measures will be distributed throughout the 45-mile reach of the Chemung River downstream from Corning and Elmira, New York. Flow regulation would also provide additional water quality enhancement in the upstream 20-mile reach between Corning and the proposed reservoirs. The benefits are widespread in scope and appear sufficient in magnitude to warrant provision of the required volume of storage for flow regulation. The primary beneficiaries are members of the public, both within and outside the Basin, who use the Chemung River for recreation or fishing or who appreciate the value of clean streams. Regulation of flow by the proposed Tioga-Hammond-Cowanesque Reservoirs would relieve the communities of Corning and Elmira of the need to provide treatment beyond 90 percent BOD removal until after year 2020.

MINE DRAINAGE

From the preceding evaluation in Chapter VIII, the alkaline waters stored in the Hammond Reservoir do not appear sufficient to neutralize the acid waters from the Tioga impoundment on a continuous basis. Since periodic acid conditions would damage or destroy the fish habitat necessary to support the fishery on a permanent basis, it is not considered to provide significant fishery benefits although some recreation benefits would accrue during periods when the Tioga flows were neutralized, the periodic loss of the fishery would greatly reduce the recreational potential.

APPENDIX A

TABLE A-1

MUNICIPAL WATER USAGE (1960)

CHEMUNG RIVER BASIN

Municipality	Population Served	Water Usage (mgd) Source	
		Ground	Surface
Addison Village	1,800	0.108	---
Alfred Village	3,500	0.150	---
Almond Village	570	0.050	---
Arkport Village	800	---	0.096
Avoca Village	1,000	0.054	---
Bath Village	5,000	0.690	---
Big Flats Town	245	0.020	---
Blossburg Borough	2,525	0.058	0.128
Bloss Township	300	---	0.020
Canisteo Village	2,550	0.150	---
Catlin Town	450	0.025	---
Cohocton Town	350	0.020	---
Cohocton Village	923	0.050	---
Corning City	17,500	2.575	---
Corning Town	900	0.055	---
Elkland Borough	2,180	0.150	---
Elmira City	71,171	3.472	6.370
Elmira Heights Village	5,139	0.308	---
Erwin Town	100	0.011	---
Greenwood Town	300	0.018	---
Hornell City	15,000	---	2.170
Horseheads Village	7,200	1.100	---
Knoxville Borough	640	0.026	---
Mansfield Borough	4,400	---	0.260
Mansfield State Teachers College	1,400	---	0.012
North Hornell Village	1,000	---	0.100
Osceola Township	208	0.008	---
Painted Post Village	3,400	0.220	---
Prattsburg Village	653	0.030	---
Riverside Village	1,030	---	0.100
South Corning Village	880	---	0.053
Tioga Borough	700	---	0.048
Troupsburg Town	150	0.013	---
Waverly	5,950	---	0.600
Wellsburg Village	614	0.065	---
Westfield Borough	1,200	0.135	---
Total	161,728	9.561	9.957

APPENDIX A

TABLE A-2

INDUSTRIAL WATER USAGE (1963)

CHEMUNG RIVER BASIN

Industry	Water Usage (mgd) Source		
	Ground	Surface	Municipal
Addison Milk Co-op	0.022	---	---
Aldenary Dairy	0.020	---	0.030
Alfred Atlas Sand and Gravel	0.216	---	---
Artistic Card Publishing Company	---	---	0.004
Bendix Corporation	1.155	---	0.130
Buckly-Nylok Company	0.025	---	---
Chemung Foundry	---	---	0.008
Corning Glass Works (at Big Flats)	0.210	---	---
Corning Glass Works (at Corning)	3.400	---	2.790
Corning Packaging Company	---	---	0.048
Dairymen's League Co-op	0.150	---	---
Elberle Tanning Company	0.400	---	---
Elkland Leather Company	0.260	2.000	0.002
Elmhurst Dairy	---	---	0.160
Erie-Lackawanna RR Repair Shop	---	---	0.111
Fawn Beverages	0.005	---	0.050
General Electric Company	0.250	---	0.002
Grandview Dairy	0.300	---	---
Great Atlantic and Pacific Tea Company	---	---	1.000
Hankins Container Company	---	---	0.009
Hardinge Brothers, Inc.	0.250	---	0.001
Hygeia Refrigeration Company	0.432	---	0.030
Ingersoll-Rand Corporation	0.260	---	0.275
Kennedy Valve Manufacturers	0.200	---	0.011
Merrill Hosiery Company	---	---	0.016
Mobil Oil Company	0.010	---	---
National Biscuit Company	---	---	0.007
New York State Electric and Gas Corporation	0.100	43.200	---
Pepsi Cola Bottling Company	---	---	0.005
Polio Dairy	0.100	---	---
Prattsburg Creamery	0.125	---	---
Reinhart Sand and Gravel	1.500	---	---
R. F. Reynolds Company	0.020	---	---
Schweizer Aircraft Corporation	0.014	---	---
Scuder and Sons Dairy	0.020	---	---
Seven-Up Bottling Company	---	---	0.002
Sperry Rand Corporation	1.660	---	0.098
Stern and Stern Textile Company	---	---	0.155

APPENDIX A

TABLE A-2 (Continued)

Industry	Water Usage (mgd) Source		
	Ground	Surface	Municipal
Thatcher Glass Manufacturers	---	---	0.532
U. S. Steel Corporation	0.040	---	0.001
Ward Lafrance Company	---	---	0.006
Westinghouse Electric Company (at Bath)	---	---	0.200
Westinghouse Electric Company (at Horseheads)	2.480	---	0.066
Total	13.624	45.200	5.749

APPENDIX B

TABLE B-1

MUNICIPAL WASTE SOURCES

CHEMUNG RIVER BASIN

Municipality	Population Served	Waste Flow (mgd)	Treatment	Waste Load Discharged, 1960 (P.E.)
Alfred Village	3,700	0.240	Secondary	---*
Bath Village	2,000	0.200	Primary	1,385*
Bath Village (Vet. Admin. Hospital)	2,450	0.199	Secondary	368*
Big Flats Town	750	0.059	Secondary	162
Blossburg Borough	1,650	0.162	None	---
Canisteo Village	2,200	0.250	Primary	1,430*
Corning City	20,285	3.000	Primary	27,495
Corning Community College	500	0.050	Secondary	75
Elkland Borough	2,150	0.200	Secondary	323*
Elmira City	50,450	5.500	Secondary	51,455
Erwin Town	1,000	0.120	Secondary	150*
Hornell City	16,917	2.000	Primary	11,437
Horseheads Town	489	0.050	Secondary	74
Mansfield Borough	3,380	0.338	None	3,380*
Painted Post Village	2,570	0.200	Secondary	740
Westfield Borough	1,200	0.205	Primary	780

* Includes industrial organic wastes.

APPENDIX B

TABLE B-2 (Continued)

Industry	Estimated Waste Flow (mgd)	Estimated P.E. Before Treatment	Treatment	Receiving Stream
Elberle Tannery	0.044	4,000	Spray Irrigation	Sub-surface
Elkland Leather Company	2.100	7,820	Spray Irrigation	Sub-surface
Elmhurst Dairy	0.016	780	---	Hornell Sewers
Erie-Lackawanna RR				
Repair Shop				
silt waste	0.050	---	None	Canisteo River
sanitary waste	0.001	10	---	Hornell Sewers
Fawn Beverages	0.005	98	None	Sub-surface
General Electric Company	0.300	---	None	Eldridge Lake
Grandview Dairy				
cooling water	0.279	---	None	Cohocton River
milk waste	0.020	N.A.	Chlorination	Cohocton River
Great Atlantic and				
Pacific Tea Company	1.000	98,000	---	Chemung Sewer District #1
Hankins Container Company				
cooling water	---	---	---	Chemung Sewer District #1
ink and paste waste	---	N.A.	---	Chemung Sewer District #1
sanitary waste	---	N.A.	---	Chemung Sewer District #1
Hardinge Brothers, Inc.				
chemical waste	---	N.A.	---	Elmira Sewers
sanitary waste	---	N.A.	---	Elmira Sewers
cooling water	0.250	---	None	Eldridge Lake
Hygeia Refrigeration				
Company				
cooling water	0.432	---	None	Chemung River
milk waste	0.012	590	---	Elmira Sewers
sanitary waste	0.001	---	---	Elmira Sewers
Ingersoll-Rand				
Corporation				
cooling water	0.240	---	---	Painted Post Sewers
process water	0.002	N.A.	None	Cohocton River
sanitary waste	0.273	2,730	---	Painted Post Sewers

APPENDIX B

TABLE B-2

INDUSTRIAL WASTE SOURCES

CHEMUNG RIVER BASIN

Industry	Estimated Waste Flow (mgd)	Estimated P.E. Before Treatment	Treatment	Receiving Stream
Addison Milk Co-op				
cooling water	0.021	--- *	None	Canisteo River
milk wastes	0.001	N.A.	None	Canisteo River
Aldenary Dairy	0.050	N.A.	None	Canisteo River
Alfred Atlas Sand and Gravel	0.450	---	Primary	Canacadea Creek
Artistic Card Publishing Company	---	N.A.	---	Elmira Sewers
Bendix Corporation	1.324	1,700	Chlorination	Newton Creek
Buckly-Nylok Company	---	N.A.	Treatment Plant	Sing Sing Creek
Corning Glass Works (at Big Flats)				
cleaning water	0.030	N.A.	None	Chemung River
cooling water	0.147	---	None	Chemung River
sanitary waste	0.033	330	---	Big Flats Sewers
Corning Glass Works (at Corning)				
cooling and process water	6.000	---	None	Chemung River
sanitary wastes	0.200	2,800	---	Corning Sewers
Corning Packaging Company				
cooling water	0.001	---	None	Bill Smith Creek
sanitary waste	0.004	40	None	Unknown
Dairymen's League Co-op				
cooling water	0.145	---	---	Chemung Sewer District #1
milk wastes	0.005	245	---	Chemung Sewer District #1
Dan's All Star Dairy				
process water	0.003	150	None	Tioga River
sanitary	---	N.A.	Septic Tank	Sub-surface

* Inventory data not available.

APPENDIX B

TABLE B-2 (Continued)

Industry	Estimated Waste Flow (mgd)	Estimated P.E. Before Treatment	Treatment	Receiving Stream
Kennedy Valve Manufacturers	---	N.A.	---	Elmira Sewers
Merrill Hosiery Company				
cooling water	0.012	---	None	Canisteo River
dye wastes	0.001	N.A.	None	Canisteo River
sanitary wastes	0.003	30	---	Hornell Sewers
Mobil Oil Company				
chemical wastes	0.100	N.A.	None	Sub-surface
sanitary wastes	0.001	10	None	Sub-surface
National Biscuit Company	---	N.A.	---	Elmira Sewers
New York State Electric and Gas Corporation				
cooling water	43.300	---	None	Chemung River
sanitary waste	0.001	10	Septic Tank	Sub-surface
slurry ash	0.270	---	Settling	Ash Pond
Pepsi-Cola Bottling Company	0.001	N.A.	None	Newtown Creek
Polio and Fiorlat Dairy	0.227	10,000	None	Cohocton River
Prattsburg Creamery				
cooling water	0.065	---	None	---
milk wastes	0.060	N.A.	Lagoons	No Discharge
Reinhart Sand and Gravel	1.500	---	Settling	Filter Pond
R. F. Reynolds Company				
cooling water	0.010	---	Secondary	Tuscarora Creek
sanitary wastes	0.025	N.A.	Secondary	Tuscarora Creek
Schweizer Aircraft Corporation				
cooling water	0.017	---	None	Sub-surface
sanitary waste	0.007	70	Septic Tank	Sub-surface
Scuder and Sons Dairy	0.020	980	None	Cohocton River
Seven-Up Bottling Company				
cooling water	0.003	---	---	Elmira Sewers
sanitary wastes	0.001	N.A.	---	Elmira Sewers

APPENDIX B

TABLE B-2 (Continued)

Industry	Estimated Waste Flow (mgd)	Estimated P.E. Before Treatment	Treatment	Receiving Stream
Kennedy Valve Manufacturers	---	N.A.	---	Elmira Sewers
Merrill Hosiery Company				
cooling water	0.012	---	None	Canisteo River
dye wastes	0.001	N.A.	None	Canisteo River
sanitary wastes	0.003	30	---	Hornell Sewers
Mobil Oil Company				
chemical wastes	0.100	N.A.	None	Sub-surface
sanitary wastes	0.001	10	None	Sub-surface
National Biscuit Company	---	N.A.	---	Elmira Sewers
New York State Electric and Gas Corporation				
cooling water	43.300	---	None	Chemung River
sanitary waste	0.001	10	Septic Tank	Sub-surface
slurry ash	0.270	---	Settling	Ash Pond
Pepsi-Cola Bottling Company	0.001	N.A.	None	Newtown Creek
Polio and Fiorlat Dairy	0.227	10,000	None	Cohocton River
Prattsburg Creamery				
cooling water	0.065	---	None	---
milk wastes	0.060	N.A.	Lagoons	No Discharge
Reinhart Sand and Gravel	1.500	---	Settling	Filter Pond
R. F. Reynolds Company				
cooling water	0.010	---	Secondary	Tuscarora Creek
sanitary wastes	0.025	N.A.	Secondary	Tuscarora Creek
Schweizer Aircraft Corporation				
cooling water	0.017	---	None	Sub-surface
sanitary waste	0.007	70	Septic Tank	Sub-surface
Scuder and Sons Dairy	0.020	980	None	Cohocton River
Seven-Up Bottling Company				
cooling water	0.003	---	---	Elmira Sewers
sanitary wastes	0.001	N.A.	---	Elmira Sewers

APPENDIX B

TABLE B-2 (Continued)

Industry	Estimated Waste Flow (mgd)	Estimated P.E. Before Treatment	Treatment	Receiving Stream
Sperry-Rand Corporation				
acid wastes	0.024	---	Neutralization	Elmira Sewers
cooling water	0.244	---	---	Elmira Sewers
plating wastes	0.300	---	---	Elmira Sewers
sanitary wastes	0.432	4,320	---	Elmira Sewers
Stern and Stern Textile Company	0.155	2,930	---	Hornell Sewers
Thacker Glass Manufacturers				
cooling water	0.471	---	---	Chemung Sewer District #1
sanitary wastes	0.060	600	---	Chemung Sewer District #1
U. S. Steel Corporation				
cooling water	0.040	---	None	Sub-surface
sanitary wastes	0.001	N.A.	Septic Tanks	Sub-surface
Ward LaFrance Company				
cooling water	0.004	---	None	Sub-surface
sanitary wastes	0.003	20	Septic Tank	Sub-surface
Westinghouse Electric Company (at Bath)				
acid wastes	0.001	---	Neutralization	Bath Sewers
cooling water	0.068	---	---	Cohocton River
sanitary wastes	0.013	130	---	Bath Sewers
Westinghouse Electric Company (at Horseheads)				
cooling water	2.448	---	---	Tributary to Newtown Creek
sanitary wastes	0.013	130	Lagoon	No Discharge

APPENDIX C

TABLE C-1

DURATION, FREQUENCY, AND STREAM FLOW CHARACTERISTICS

TIOGA RIVER AT TIOGA, PENNSYLVANIA

Location--Lat 41°54'30", Long 77°07'45", 130 ft. upstream from highway bridge at Tioga, Tioga County, and three-quarters of a mile upstream from Crooked Creek.

Drainage Area--282 sq. mi.

Tributary to--Chemung River.

Average Discharge--24 years, 333 cfs.

Extremes--1938-62: Maximum discharge, 39,000 cfs, May 27, 1946; minimum discharge, 4.5 cfs, August 10, 11, 1955.

Period of Consecutive Days	Magnitude and Frequency of Annual Low Flow Period 1939-59 Discharge, in cubic feet per second, for indicated recurrence interval, in years.				
	2	3	5	10	25
7	16	12	10	7.7	5.7
14	20	16	12	9.3	6.8
30	23	18	15	11	8.2
60	28	23	18	14	10
120	44	34	28	22	18

Duration Table of Daily Flow
Period 1939-60
Discharge, in cubic feet per second, which was equalled or exceeded for indicated percent of time.

%	2	5	10	20	30	40	50	60	70	80	90	95	98
cfs	2,200	1,350	800	465	290	200	135	90	59	38.5	25	18.5	13.8

APPENDIX C

TABLE C-2

DURATION, FREQUENCY, AND STREAM FLOW CHARACTERISTICS

CROOKED CREEK AT TIOGA, PENNSYLVANIA

Location--Lat 41°54'05", Long 77°08'55", at New York Central Railroad Bridge, one mile southwest of Tioga, Tioga County, one mile upstream from Elkhorn Creek, and three miles upstream from mouth.

Drainage Area--122 sq. mi.

Tributary to--Tioga River.

Average Discharge--9 years, 112 cfs.

Extremes--1953-62: Maximum discharge, 10,900 cfs, October 14, 1966; Minimum discharge 2.1 cfs, August 24, 26, 1962.

Low-flow Frequency--Estimated average annual minimum discharges for seven consecutive days.

Recurrence Interval	2 years	10 years
Discharge	4.6 cfs	2.4 cfs

Basis of Estimate--Correlated with Tioga River at Tioga using concurrent daily discharges.

Duration Table of Daily Flow
Period 1954-60
Discharge, in cubic feet per second, which was equalled or exceeded for indicated percent of time.

2	5	10	20	30	40	50	60	70	80	90	95	98
880	470	265	140	85	56	37	25	17	10	5.8	4.5	3.5

APPENDIX C

TABLE C-3

DURATION, FREQUENCY, AND STREAM FLOW CHARACTERISTICS

COWANESQUE RIVER NEAR LAWRENCEVILLE, PENNSYLVANIA

Location--Lat 41°59'10", Long 77°09'00", three-quarters of a mile downstream from Cook Creek, one and three-fourths miles southwest of Lawrenceville, Tioga County, and two and one-half miles upstream from the mouth.

Drainage Area--295 sq. mi.

Tributary to--Tioga River.

Average Discharge--11 years, 290 cfs.

Extremes--1951-62: Maximum discharge, 18,300 cfs, April 25, 1961; Minimum discharge, 0.8 cfs, August 31, September 1, 1962.

Low-flow Frequency--Based on eight years of record.

Recurrence Interval	2 years	10 years
Discharge	5.0 cfs	2.0 cfs

Duration Table of Daily Flow
Period 1952-60
Discharge, in cubic feet per second, which was equalled or exceeded for indicated percent of time.

2	5	10	20	30	40	50	60	70	80	90	95	98
2,200	1,200	730	380	240	140	90	55	31	17	8.8	5.6	3.9

APPENDIX C

PART B (cont.)

DURATION, FREQUENCY, AND SUMMARY FLOW CHARACTERISTICS

TIOGA RIVER AT LINDLEY, NEW YORK

Location--Lat 42°01'45", Long 77°07'55", on left bank just downstream from highway bridge at Lindley, Steuben County, six miles upstream from Canisteo River.

Drainage Area--770 sq. mi.

Average Discharge--30 years, 812 cfs.

Minimum Discharge--7.2 cfs.

Minimum Average Discharge, in cfs, for Indicated Length of Period, Based on 1930-59 Records

Period	Discharge	Period	Discharge
3-day	7.8	90-day	26.7
7-day	9.5	120-day	33.6
14-day	11.2	150-day	37.4
30-day	12.7	183-day	36.5
60-day	19.0	274-day	122

Magnitude and Frequency of Annual Low Flow Based on 1930-59 Records

Period (Consecutive days)	Discharge in cfs, for indicated recurrence intervals in years				
	2	5	10	20	30
1	33	18	13	9.8	8.6
7	39	21	15	11	9.6
30	52	27	19	14	12

Duration of Daily Discharge
Water Years 1931-60
Discharge, in cfs, which was equalled or exceeded for indicated percent of time.

1	5	10	15	20	30	40	50	60	70	80	85	90	95	98	99	99.5	99.9
7,500	3,300	2,050	1,450	1,050	670	430	290	195	130	84	65	50	37	26	20	16	11

Remarks--No known regulation or diversion.

APPENDIX C

TABLE C-5

DURATION, FREQUENCY, AND STREAM FLOW CHARACTERISTICS

CANISTEO RIVER AT WEST CAMERON, NEW YORK

Location--Lat 42"13'20", Long 77°25'05", on right bank 250 ft. downstream from highway bridge, one quarter of a mile southeast of West Cameron, Steuben County, and one and one-half miles north of Cameron.

Drainage Area--342 sq. mi.

Average Discharge--24 years, 358 cfs.

Minimum Daily Discharge--12 cfs.

Minimum Averege Discharge, in cfs, for Indicated Length of Period, Based on 1937-59 Records

Period	Discharge	Period	Discharge
3-day	12.0	90-day	23.0
7-day	12.1	120-day	25.8
14-day	12.9	150-day	27.0
30-day	15.3	183-day	30.2
60-day	19.2	274-day	59.4

Magnitude and Frequency of Annual Flow
Based on 1937-59 Records

Period (Consecutive days)	Discharge in cfs, for indicated recurrence intervals in years				
	2	5	10	20	30
1	25	17	15	13	12
7	28	19	16	14	13
30	34	22	19	17	15

Duration of Daily Discharge
Discharge, in cfs, which was equalled or exceeded for indicated percent of time.

Water Years	1	5	10	15	20	30	40	50	60	70	80	85	90	95	98	99	99.5	99.9
1931, 1938-60	3,700	1,450	850	590	440	275	190	130	88	62	45	39	33	26	21	19	17	15
1931-60	3,600	1,450	840	560	410	245	165	115	85	62	45	39	33	26	21	19	17	15

Remarks--Flood flows regulated by Arkport Reservoir since November 1939 and Almond Reservoir since October 1948; normal regulation insufficient to materially affect figures of monthly run-off.

APPENDIX C

TABLE C-8

DURATION, FREQUENCY, AND STREAM FLOW CHARACTERISTICS

CHEMUNG RIVER AT CHEMUNG, NEW YORK

Location--Lat 40°00'10", Long 76°38'00", on right bank 60 ft. downstream from highway bridge, three-quarters of a mile southwest of Chemung, Chemung County, and ten miles upstream from mouth.

Drainage Area--2,530 sq. mi.

Average Discharge--54 years (1905-13, 1914-60), 2,530 cfs.

Minimum Daily Discharge--5.2 cfs, 7.2 cfs (based on 40 climatic years, 1915-59).

Minimum Average Discharge, in cfs, for Indicated Length of Period, Based on 40 Climatic Years, 1915-59

Period	Discharge	Period	Discharge
3-day	75.3	90-day	117
7-day	76.9	120-day	133
14-day	78.4	150-day	141
30-day	88.9	183-day	148
60-day	102	274-day	381

Magnitude and Frequency of Annual Low Flow Based on 40 Climatic Years, 1915-59

Period (Consecutive days)	Discharge in cfs, for indicated recurrence intervals in years				
	2	5	10	20	30
1	160	105	84	74	71
7	180	115	92	81	77
30	210	135	110	96	90

Duration of Daily Discharge

Water Years	Discharge, in cfs, which was equalled or exceeded for indicated percent of time																	
	1	5	10	15	20	30	40	50	60	70	80	85	90	95	98	99	99.5	99.9
1916-60	24,000	10,000	6,200	4,400	3,300	2,100	1,400	990	700	490	340	280	220	170	130	115	100	83
1931-60	23,500	9,900	6,100	4,300	3,300	2,100	1,450	980	680	470	315	255	205	155	125	110	97	80

Remarks--High flows slightly regulated by upstream reservoirs. During each year a large part of flow from 45 sq. mi. is diverted from Mud Creek, an upstream tributary, into Keuka Lake (Oswego River Basin) for power development.

APPENDIX D

TABLE D-1

HISTORICAL AND PROJECTED POPULATION

TIOGA AND CHEMUNG RIVER BASINS

(Percentage Change for Prior 10 Years)	1940	1950	1960	1970	1980	1990	2000	2010	2020
Chemung County, N.Y.	73,718	86,827	98,706						
Percentage Change		17.8	13.7						
Steuben County, N.Y.	84,927	91,439	97,691						
Percentage Change		7.7	6.8						
Potter County, Pa.	18,201	16,810	16,483						
Percentage Change		-7.6	-2.0						
Tioga County, Pa.	35,004	35,474	36,614						
Percentage Change		1.3	3.2						
Total	211,850	230,550	249,494						
Economic Sub-Region		355,600	385,600	462,000	586,900	704,200	859,700	1,057,400	1,304,200
Percentage Change			8.4	19.8	27.0	20.0	22.1	23.1	23.3
Municipal Areas									
Elmira (Chemung, N.Y.)	72,663	85,578	97,421	122,000	163,000	206,000	264,000	339,000	441,000
Bath (Steuben, N.Y.)	9,354	10,926	11,978	16,000	22,000	28,000	37,000	49,000	64,000
Corning (Steuben, N.Y.)	27,326	31,422	36,172	44,000	58,000	73,000	91,000	112,000	149,000
Hornell (Steuben, N.Y.)	21,791	21,529	20,972	22,000	25,000	26,000	28,000	31,000	34,000
Mansfield (Tioga, N.Y.)	3,033	3,802	4,029	4,600	5,800	7,000	8,600	11,000	13,000

APPENDIX D

TABLE D-2

INDICES OF INDUSTRIAL OUTPUT

TIOGA AND CHEMUNG RIVER BASINS
(INDEX OF OUTPUT 1960 = 100)

SIC	Description	1970	1980	1990
Chemung County				
2026	Fluid Milk	158	245	363
2033	Canned Fruits, Vegetables, Preserves	114	172	255
2086	Bottled and Canned Soft Drinks	150	276	508
2097	Manufactured Ice	127	183	270
2653	Corrugated and Solid Fiber Boxes	95	136	155
2771	Greeting Card Publishing	122	133	139
3221	Glass Containers (Corning)	122	137	157
3221	Glass Containers (Thatcher)	155	225	325
3321	Gray Iron Foundries	100	118	124
3441	Fabricated Structural Steel	97	103	151
3541	Machine Tools, Metal Cutting Types	143	187	246
3494	Valves and Pipe Fittings, excl. Plumbers	163	228	379
3572	Typewriters	170	268	433
3673	Transmitting, Industrial, and Special Electron Tubes	302	685	1,081
3711	Motor Vehicles	78	15	0
3729	Aircraft Parts and Auxiliary Equipment	412	907	1,307
Broome County				
1941	Sighting and Fire Control Equipment	119	183	257
2013	Sausages and Other Prepared Meats	171	272	422
2023	Condensed and Evaporated Milk	156	241	357
2026	Fluid Milk	183	332	578
2071	Candy and Other Confectionery Products	97	133	187
2653	Corrugated and Solid Fiber Boxes	202	98	47
2844	Perfumes, Cosmetics, and Other Preparations	163	270	463
3141	Footwear, excl. House Slippers	60	39	26
3251	Brick and Structural Clay Tile	156	231	307
3391	Iron and Steel Forgings	134	189	266
3494	Valves and Pipe Fittings, excl. Plumbers	50	0	0
3572	Typewriters	171	270	439
Steuben County				
1441*	Sand and Gravel	155	210	275
2021	Creamery Butter	161	250	370
2023	Condensed and Evaporated Milk	159	247	365
2024	Ice Cream and Frozen Desserts	157	244	361
2026	Fluid Milk	155	240	356

* Now 1442

APPENDIX D

TABLE D-2 (Continued)

SIC	Description	1970	1980	1990
2033	Canned Fruits, Vegetables, Preserves	114	172	255
2231	Broad Woven Fabric Mills	103	68	37
2251	Womens Hosiery, Seamless and Full-fashioned	122	91	55
2653	Corrugated and Solid Fiber Boxes	95	123	155
3229	Pressed and Blown Glassware, nec.	148	167	190
3561	Pumps, Air and Gas Compressors	197	314	517
3671	Radio and Television Receiving Type Tubes	281	619	965
Tioga County				
2023	Condensed and Evaporated Milk	106	112	109
3111	Leather Tanning and Finishing	62	33	17
3229	Pressed and Blown Glassware, nec.	122	137	157
3494	Valves and Pipe Fittings, excl. Plumbers	83	70	87
3694	Electrical Equipment for Internal Combustion Engines	131	152	188

APPENDIX E

TABLE E-1

1965-1968 WATER QUALITY SAMPLING RESULTS
FWPCA, CB-SRBP

TIOGA RIVER

Date			Water Temp.	Stream Flow	D.O.	BOD_5	Total Hard.	Chl.	Net Alk. mg/l	Cond. μ-mho		Total Iron	Mang.	Sulfate
Yr	Mo	Da	°C.	cfs	mg/l	mg/l	mg/l	mg/l	(as $CaCO_3$)	cm	pH	mg/l	mg/l	mg/l
Station Number TIO 087 (Station at Blossburg, Pa., immediately upstream from Morris Run Confluence)														
65	07	16	17.0	4.0	9.1				6.9	34	7.0			
65	08	23	16.0	3.7	12.5	27.6	42.1		15.4	153	6.9			182
65	08	24	13.0	3.2	10.3		32.3	3.0	-4.0	61	6.8			
65	08	25	14.0	3.0	9.9	7.7	47.5		3.7	251	7.5			52.9
65	10	27	10.0	9.5			71.7		9.6	200	7.5			44.1
66	05	04		126					-1.2	67	5.7	0.2	0	14.7
66	05	18		117					-2.5	40	6.0	0.1	0	14.7
66	06	10		9.6					3.9	46	7.3	0.16	0.02	184
66	06	14		5.7					15.6	52	7.5	0.19	0	118
66	07	19		3.5					3.7	50	6.8	0.04	0.05	
68	08	15		8.4					-126	59	3.6	0.23	0.13	78
68	09	12		85.3					11.4	66	6.0	0.30	0.3	63
68	10	22		10.1					45.8	50	6.5	0.13	0.12	23.5
Station Number TIO 080														
65	09	22	21.1	10.4			291		-20.1	760	3.2			364
65	09	29	12.8				266		-14.8	725	3.6			350
65	10	06	4.4	14.4			248		-31.3	700	3.5			350
65	10	13	8.3	25.6			217		-23.7	580	3.4			302
65	10	20	10.0	15.8			246		-31.1	690	3.5			401
65	10	27	8.9	19.0			213		-16.9	650	3.5			316
65	11	03	6.7	17.0			186		-33.4	680	3.8			308
66	05	04		214					-35.2	240	3.9	4.1	1.8	132
66	05	18		195					-47.9	250	3.8	3.0	4.0	95.5
66	06	08		18.5					-69.1	355	3.4	3.2	3.5	176
66	06	14		30.5					-85.7	410	3.2	3.0	3.2	220
66	07	19		11					-215	750	3.2	8.0	9.8	433

APPENDIX E

TABLE E-1 (Continued)

Date			Water Temp.	Stream Flow	D.O.	BOD_5	Total Hard.	Chl.	Net Alk. mg/l (as $CaCO_3$)	Cond. µ-mho/cm	pH	Total Iron	Mang.	Sulfate
Yr	Mo	Da	°C.	cfs	mg/l	mg/l	mg/l	mg/l				mg/l	mg/l	mg/l
Station Number TIO 072														
65	09	22	21.7	11.8			264		-2.1	570	4.0	0.80	3.8	268
65	09	29	12.8	14.4			199		-14.9	540	4.0	1.00	3.5	274
65	10	06	5.0	15.8			253		-16.4	520	4.2	1.80	3.2	247
65	10	13	9.4	29.0			198		-3.2	450	4.1	1.00	2.4	233
65	10	20	10.0	18.0			233		-17.7	500	4.0	3.00	4.8	283
65	10	27	8.9	27.8			215		-10.8	490	4.0	2.00	2.7	235
65	11	03	4.4	19.7			155		-13.6	500	4.2	6.50	3.2	176
66	05	04		337					-18.2	170	4.7	2.6	0.6	110
66	05	18		236					-33.8	160	4.5	0.6	3.0	73.4
66	06	14		52					-59.4	952	3.6	1.7	2.0	139
66	07	19		11.2					-144	510	3.6	1.5	8.8	316
68	08	15		29.9					-108	500	3.5	2.2	6.4	29.2
68	09	12		330					-0.2	210	5.2	2.1	2.8	125
68	10	22		25.7					-159	430	4.4	2.5	5.8	251
Station Number TIO 067														
65	07	16	25.0	19.0	9.1				-47.8	253	4.6			
65	08	30	11.0	14.0	9.6	4.6	175	10.5	-42	317	5.0	0.2		
65	08	31	14.0	13.0	8.5		190		-72	358	4.7	5.7		197
65	09	01	12.0	17.0	10.4			10	-36	357	5.5	0.7		
65	09	13	15.0	21.0	10.2				-70.1	357	4.9			
65	09	16	21.0	18.0	9.0	2.5			-5	395	4.9			
Station Number TIO 065 (Proposed site of Tioga River Reservoir, immediately upstream from confluence of Crooked Creek)														
65	06	28	24.0	51.6	9.6				-25.2	350	4.5			
65	07	19	21.0	14.0	9.4				-69.5	380	4.5			
65	08	30	11.0	16.1	8.3	18.0	182	11.5	-40.0	390	5.2	1.6		174
65	08	31	14.0	15.3	7.9		175		-49	420	5.1	2.0		179
65	09	01	15.0	20.2	9.8				-30	405	5.5	2.4		
65	09	16	20.0	21.2	9.5	1.5			-5	405	4.9			
65	09	20	22.0	15.0			221.4		-111	770	3.0			117
65	09	22	21.1	13.0			245		-41.4	440	5.0	0.16	2.4	199
65	10	06	5.0				228		-77.7	390	5.1	0.60	2.2	178

APPENDIX E

TABLE E-1 (Continued)

Date Yr	Mo	Da	Water Temp. °C.	Stream Flow cfs	D.O. mg/l	BOD_5 mg/l	Total Hard. mg/l	Chl. mg/l	Net Alk. mg/l (as $CaCO_3$)	Cond. µ-mho cm	pH	Total Iron mg/l	Mang. mg/l	Sulfate mg/l
Station Number TIO 065 (Continued)														
65	10	13	9.4	32.0			182		-43.3	360	5.0	0.50	1.7	192
65	10	20	9.4	20.0			201		-77.1	380	4.8	0.10	2.2	257
65	10	27	9.4	28.0			181		-58.6	380	4.8	0.40	2.2	184
65	11	03	4.4	22.0			179		-60.9	370	5.1	0.50	2.2	206
66	05	04		460					-6.9	140	5.7	0.8	0.8	44.1
66	05	18		406					-16.7	129	5.3	0.15	1.8	44.1
66	06	08		72					-31.7	253	3.8	0.37	2.0	176
66	06	09		65					-22.6	210	4.2	0.33	2.2	132
66	06	14		64					-24.0	213	4.7	0.20	1.6	169
66	07	19		14					-60.9	350	4.6	0.38	6.3	228
68	04	03		719					3.0	80	6.0	1.25	0.9	75.4
68	06	13		2630					8.4	118	6.4	1.5	0.77	39.0
68	08	15		50.3					-52.6	345	4.6	0.31	4.3	43.8
68	09	12		586					7.6	180	6.6	0.55	1.6	62.6
68	10	22		47.9					-46.5	300	4.7	0.05	4.1	178
Station Number TIO 061 (Station downstream from Crooked Creek Confluence)														
65	06	28	19.0	49.9	8.0				-2.7	290	5.5			
65	07	19	21.0	21.5	9.5				-1.2	200	5.3			
65	09	20	22.0	18.2			217		-10.1	310	5.5	0.22	2.8	130
65	09	22	22.2	15.7			195		-10.0	340	5.3	0.12	1.4	151
65	09	24	13.3	17.8			184		-17.1	330	5.0	1.3	1.6	172
65	10	06	6.1	20.5			194		-24.6	325	5.3	0.2	1.6	137
65	10	13	10.0	38.6			176		-10.3	310	5.7	0.2	1.2	134
65	10	20	10.0	25.6			150		-21.3	330	5.4	0.1	1.6	193
65	10	27	9.4	36.4			150		-14.1	325	5.8	0.2	1.6	132
65	11	03	4.4	29.7			190		-17.7	340	6.0	0.23	1.6	143
66	05	18		536					5.6	110	8.3	0.17	1.0	36.7
66	06	08		94						239	7.4	0.27	1.5	58.8
66	06	14		91					13.4	170	7.0	0.19	0.8	58.8
66	07	19		19.8					1.2	275	5.6	0.16	3.5	118
68	04	03		990					11.7	113	6.8	0.82	0.58	58.7
68	06	13		2886					16.5	105	7.0	1.05	0.63	19.5

APPENDIX E

TABLE E-1 (Continued)

Date Yr	Mo	Da	Water Temp. °C.	Stream Flow cfs	D.O. mg/l	BOD_5 mg/l	Total Hard. mg/l	Chl. mg/l	Net Alk. mg/l (as $CaCO_3$)	Cond. µ-mho cm	pH	Total Iron mg/l	Mang. mg/l	Sulfate mg/l
Station Number TIO 061 (Continued)														
68	08	15		62.2					0.9	260	6.5	0.15	2.75	124
68	09	12		661					14.1	170	6.9	0.73	1.25	62.6
68	10	22		60.5					-18	250	5.4	0.28	2.75	124
Station Number TIO 059														
65	07	19	21.0	39.2	9.6				-29.8	255	6.6			
65	08	30	17.0	24.7	9.4	5.8	182	10.5	-20	337	5.1	0.6		199
65	08	31	16.0	16.9	8.8		167		-7	312	5.2	15.5		192
65	09	01	15.0	17.5	12.7			10	-3.6	299	6.1	0.4		
65	09	13	16.0	22.7	8.5				-2.2	304	5.8			
65	09	16	18.0	34.1	9.2	2.5			-2.0	330	5.7			
Station Number TIO 056 (Station downstream from Cowanesque River Confluence)														
65	07	20	18.0	49.3	7.8				26.8	243	7.4			
65	08	30	13.0	28.0	8.5	20.0	165	24.5	176	341	7.4	1.1		124
65	08	31	16.0	20.2	8.8		157		-1.0	354	6.1	2.7		119
65	09	01	16.0	22.6	9.6		32	23	-9.0	386	5.9	0.8		
65	09	13	26.0	31.3	7.5				16.8	409	6.5			
65	09	20	20.0	31.3	6.0	3.4			35.0	419	6.9			
65	09	24	21.0	22.6	6.0	2.3			30.0	358	7.1			
68	04	03		1671					20.5	120	7.2	0.96	0.43	75.4
68	06	13		1920					24.1	120	6.5	0.85	0.45	32.5
68	08	15		66					21.4	300	7.3	0.24	1.30	102
68	09	12		638					26.5	190	7.4	0.63	1.00	407
68	10	22		80.4					6.4	400	6.6	0.21	2.60	137
Station Number TIO 048 (Station downstream from Canisteo River)														
65	07	20	18.0	133.6	8.5				105.3	268	8.2			
65	08	30	13.0	62.0	8.5	4.2	139	25.5	92.8	300	8.0	3.7		103
65	08	31	16.0	62.0	9.4		134		94	298	8.3	7.7		101
65	09	01	19.0	66.0	13.4			26	78	313	7.3	3.2		
65	09	20	17.0	85.8	11.7	3.7			132	445	8.6			
65	09	24	21.0	67.1	8.4	2.0			130	382	8.1			

APPENDIX E

TABLE E-1a

PENNSYLVANIA WATER QUALITY DATA

TIOGA RIVER AT TIOGA

Date			Flow	Alk.	Alk.
Yr	Mo	Da	(cfs)	(mg/l)	(#/day)
62	05	23	83	-3	-1,300
62	08	14	15	-100	-8,100
62	11	07	77	-2	-800
63	05	15	268	+5	+7,200
63	08	20	18	-58	-5,600
63	11	13	440	-66	-156,800
64	02	05	270	-10	-14,600
64	05	07	430	-4	-9,300
64	08	04	17	-27	-24,800
65	05	04	478	+8	+20,600
65	07	21	20	-38	-4,100
65	10	21	21	-80	-8,600
66	01	20	100	-42	-22,700
66	04	19	173	-14	-13,000
66	07	07	28	-59	-8,900

APPENDIX E

TABLE E-2

1965-1968 WATER QUALITY SAMPLING RESULTS
FWPCA, CB-SRBP

CROOKED CREEK

Date			Water Temp.	Stream Flow	D.O.	BOD_5	Total Hard.	Chl.	Net Alk. mg/l (as $CaCO_3$)	Cond. μ-mho		Total Iron	Mang.	Sulfate
Yr	Mo	Da	°C.	cfs	mg/l	mg/l	mg/l	mg/l		cm	pH	mg/l	mg/l	mg/l
Station Number CRK 016														
65	06	28	24.5	4.9	9.6					195	6.8			
65	07	19	20.0	3.2	9.8				144	198	8.0			
65	08	23	16.0	1.9	8.2	26.8	108		134	185	7.4			204
65	08	24	17.0	1.6	7.7		111	8.0	160	199	7.3			
65	08	25	19.0	1.5	8.0	3.5	111		139	199	7.7			
65	08	26	21.0	1.8	6.6		108		134	210	8.0			
Station Number CRK 012														
65	06	28	19.0	6.3	6.3				73.5	195	7.5			
65	07	19	20.0	5.3	9.4				194	220	8.0			
65	08	23	17.0	2.4	7.4	26.0	87		148	206	7.4			320
65	08	24	17.0	2.1	8.5		104.5	11.5	135	205	7.8			
65	08	25	19.0	1.9	7.5	3.3	104.1		139	207	7.5			80.6
65	08	26	21.0	2.2	7.5		101		136	222	7.5			
Station Number CRK 007														
65	06	28	25.0	7.1	8.8					180	7.2			
65	07	19	22.0	4.6	8.5					205	7.3			
65	08	23	17.0	2.7	8.2	5.2	87.0		11.7	172	7.2			68.2
65	08	24	17.0	2.4	7.8		40.5	7.5	34.0	159	7.5			
65	08	25	19.0	2.2	8.0	3.2	93.5		10.3	169	7.8			113.4
65	08	26	21.0	2.5	7.5		82.5			178	7.7			
Station Number CRK 002														
65	06	28	24.5	7.5	8.3					183	7.2			
65	07	19	22.0	4.9	6.2				68.5	185	6.7			
65	08	23	18.0	2.9	6.0	25.3	90.5		118.0	173	7.1			447.0
65	08	24	17.0	2.5	6.1		87.7	7.0	16.0	161	7.2			
65	08	25	20.0	2.3	7.0	28.0	93.5		116.0	175	7.5			141.1
65	08	26	21.0	2.7	8.0		86.5		105.0	178	7.8			

APPENDIX E

TABLE E-2 (Continued)

Date			Water Temp.	Stream Flow	D.O.	BOD_5	Total Hard.	Chl.	Net Alk. mg/l (as $CaCO_3$)	Cond. µ-mho		Total Iron	Mang.	Sulfate
Yr	Mo	Da	°C.	cfs	mg/l	mg/l	mg/l	mg/l		cm	pH	mg/l	mg/l	mg/l
Station Number CRK 000														
65	06	28	27.0	7.6	3.4				56.7	150	9.4			
65	07	19	22.0	5.0	0.1				147	164	8.3			
65	08	30	16.0	2.1	8.7	3.5		8.0	100	161	7.8			73.1
65	08	31	16.0	2.3	7.7		75.0		100	179	8.1			
65	09	01	18.0	3.2	10.8			7.5	101	172	8.3			
65	09	13	20.0	3.8	8.9				126	198	8.1			
65	09	16	20.0	3.2	12.9				67	183	9.4			
65	09	20					137		34	195	7.8	0.12		
65	09	22					135		62	180	8.2	0.12		42
65	09	29					123		105	175	8.0	0.1		42
65	10	06					119		80	180	7.0	0.1		62
65	10	13					139		84	195	7.0	0.1		65
65	10	20					137		80	200	6.3	0.3		41
65	10	27					141		82	220	7.3	0.2		29
65	11	03					94		82	230	7.0	0.19		55
66	05	04		148					27.1	120	7.2	0.14	0.0	36.72
66	05	18		127					30.5	100	6.3	0.27		29.38
66	06	08		19					49.11	115	7.8	0.44	0.0	44.1
66	06	09		16					89.72	123	7.4	0.32	2.2	51.4
66	06	14		23.0					54.35	138	7.5	0.29	0.0	36.72
66	07	19		5.8					73.4	155	8.1	0.02	0.05	29.38
68	04	03		271.2					24.7	98	7.2	0.68	0.08	16.76
68	06	13		255.8					40.4	120	6.8	0.90	0.72	13.0
68	08	15		11.95					66.7	170	7.3	0.32	0.03	116.8
68	09	12		240.7					53.4	160	7.2	0.53	0.00	31.3
68	10	22		12.6					71.8	160	6.3	0.08	0.03	20.1

APPENDIX E

TABLE E-3

1965 WATER QUALITY SAMPLING RESULTS
FWPCA, CB-SRBP

COWANESQUE RIVER

Date			Water Temp.	Stream Flow	D.O.	BOD_5	Total Hard.	Chl.	Net Alk. mg/l (as $CaCO_3$)	Cond. μ-mho	pH	Total Iron	Mang.	Sulfate
Yr	Mo	Da	°C.	cfs	mg/l	mg/l	mg/l	mg/l		cm		mg/l	mg/l	mg/l
Station Number COW 027 (Station near Westfield, Pa.)														
65	06	24	17.5		2.0					145	6.5			
65	07	14	20.0	2.2	9.3	4.5			98	140	8.0			
65	08	16	24.0	2.9	6.5	5.1		19	74	168	7.3			
65	08	17	21.0	2.3	7.5			16	101	202	7.5			
65	08	18	23.0	2.2	8.0	2.9	81		104	203	7.5			3.8
65	08	19	23.0	1.9	5.2		77		106	179	7.6			3.8
Station Number COW 026 (Station near Westfield, Pa.)														
65	07	14	27.0	2.6	4.8	2.2			77	495	7.7			
65	08	16	25.0	3.4	4.6	30.0		195	173	449	7.5			15.2
65	08	17	24.0	2.7	4.5			200	204	600	7.5			
65	08	18	23.0	2.6	4.2	74.0	176		299	624	7.7			8.8
65	08	19	23.0	2.2	3.4		182		246	692	7.4			
Station Number COW 023														
65	06	24	21.0		2.0					425	6.8			
65	07	14	27.0	3.8	11.7	1.7			199	455	8.3			
65	08	16	25.0	5.0	2.6	14.4		113	162	410	7.5			17.6
65	08	17	23.0	3.9	2.2			129	176	454	7.6			
65	08	18	23.0	3.8	2.1	34.0	146		195	513	7.6			3.8
65	08	19	24.0	3.1	1.6		148		206	529	7.2			
Station Number COW 020														
65	06	24	23.0	6.2	2.0					340	6.8			
65	07	14	27.0	8.2	8.6	1.3			128	325	8.0			
65	08	16	24.0	6.5	4.6	2.2		76	156	361	7.5			10.2
65	08	17	23.0	6.2	3.8			74	156	344	7.5			
65	08	18	23.0	4.9	2.6	1.6	122		157	370	7.5			3.8
65	08	19	23.0		2.7		114		147	364	7.0			

APPENDIX E

TABLE E-3 (Continued)

Date Yr	Mo	Da	Water Temp. °C.	Stream Flow cfs	D.O. mg/l	BOD_5 mg/l	Total Hard. mg/l	Chl. mg/l	Net Alk. mg/l (as $CaCO_3$)	Cond. µ-mho/cm	pH	Total Iron mg/l	Mang. mg/l	Sulfate mg/l
Station Number COW 015														
65	06	24	21.5		2.0					340	6.6			
65	07	14	27.0	7.3	6.9	1.3			140	293	7.7			
65	08	16	25.0	9.5	4.2	2.4		64	129	310	7.2			10.2
65	08	17	24.0	7.6	3.8			64	129	307	7.2			
65	08	18	24.0	7.2	3.4	1.8	166		189	312	7.2			3.8
65	08	19	23.0	5.8	2.9		98		123	310	6.6			
Station Number COW 013 (Station upstream from Elkland, Pa.)														
65	06	24	23.0		10.8				80	300	8.3			
65	07	15	24.0	7.7	10.5				124	270	8.6			
65	08	16	24.0	10.1	6.7	2.6		70	131	307	7.6			12.6
65	08	17	24.0	8.1	6.9			65	131	304	7.6			
65	08	18	23.0	7.6	4.5	4.6	171		134	301	7.1			3.8
65	08	19	24.0	6.1	3.4		146		120	304	6.5			
Station Number COW 008														
65	06	24	24.0		2.0					500	7.0			
65	07	15	23.0	8.4	10.5				168	505	8.7			7.5
65	08	16	23.0	11.1	4.3	3.3		294	209	791	7.6			
65	08	17	25.0	8.9	4.5			405	201	769	7.6			
65	08	18	24.0	8.4	5.6	3.7	161		202	718	7.5			5.1
65	08	19	24.0	6.7	3.1		161		191	767	6.9			
Station Number COW 005														
65	06	24	26.0		2.0					430	6.5			
65	07	15	25.0	8.8	9.5				158	505	8.2			
65	08	16	24.0	11.6	4.9	3.2		254	178	729	7.6			15.2
65	08	17	24.0	9.2	5.3			253	162	692	7.6			
65	08	18	24.0	8.8	3.8	3.1	127		142	685	7.5			63
65	08	19	24.0	6.9	4.3		115		126	660	6.9			63

APPENDIX E

TABLE E-3 (Continued)

Date			Water Temp.	Stream Flow	D.O.	BOD_5	Total Hard.	Chl.	Net Alk. mg/l (as $CaCO_3$)	Cond. μ-mho	pH	Total Iron	Mang.	Sulfate
Yr	Mo	Da	°C.	cfs	mg/l	mg/l	mg/l	mg/l		cm		mg/l	mg/l	mg/l
Station Number COW 003 (Proposed Site of the Cowanesque Reservoir)														
65	06	24	28.0		7.5				59	400	8.7			
65	07	15	25.0	9.1	10.5				170	505	8.4			
65	08	17	25.0	9.6	6.9		127	239	143	662	7.7			7.5
65	08	18	24.0	9.1	6.2	3.0	127		140	662	7.5			5.1
65	08	19	25.0	7.2	4.9		117		129	655	7.0			
Station Number COW 001														
65	06	24	26.0		11.0					400	8.1			
65	07	15	25.0	9.6	10.4				133	535	8.5			
65	07	19	22.0	9.2	9.6				135	480	8.3			
65	08	16	24.0	12.1	5.3	3.2		235	120	647	7.7			75
65	08	30	16.0	3.3	7.1	14.0		139	96	523	7.8			176
65	08	31	17.0	3.6	7.7		75		98	566	7.8			68
65	09	01	19.0	5.5	8.5				99	601	8.1			176
65	09	13	20.0	8.2	7.5		75	152	129	650	7.7			68
65	09	16	23.0	13.2	13.2	1.2			75	952	8.8			

APPENDIX E

TABLE E-3a

1968 WATER QUALITY DATA

COWANESQUE RIVER

Date Yr Mo Da	Stream Flow cfs	D.O. mg/l	BOD_5 mg/l	Net Alk. mg/l (as $CaCO_3$)	Cond. u-mho cm	pH	Total Iron mg/l	SO_4 mg/l	Mg mg/l	Ca Mg/l	Mn mg/l	Al mg/l	Cr mg/l	Ni mg/l	Cu mg/l	Zn mg/l
Station Number COW 008																
68 10 21	17.0	6.3	3.8	131.8	800	7.7	0.2	70.4	13.0	60.5	0.30	0.1	0.0	0.0	0.036	0.0
68 10 22	17.0	4.62	4.2	138.3	910	7.4	0.18	93.9	11.5	58.0	0.41	0.0	0.0	0.0	0.026	0.0
Station Number COW 001																
68 08 15	24			82.1	465	8.0	0.23	73.3		31.8	0.03					
68 09 12	301			77.5	310	7.6	0.18	430		32.5	0.03					
68 10 22	20.0			91.6	600	6.4	0.20	80.4		45.5	0.04					

APPENDIX E

TABLE E-4

1965 WATER QUALITY SAMPLING RESULTS
FWPCA, CB-SRBP

CANISTEO RIVER

Date Yr	Mo	Da	Water Temp. °C.	Stream Flow cfs	D.O. mg/l	BOD_5 mg/l	Net Alk. mg/l (as $CaCO_3$)	Cond. μ-mho/cm	pH
Station Number CAN 045									
65	07	07	24.0	1.6	12.3		248	280	8.2
65	08	02	19.0	0.8	15.7		279	255	7.6
65	08	04	14.0	0.7	10.4		290	239	8.5
65	08	09	23.0	1.1	9.6		291	310	8.3
65	08	11	20.0	1.6	11.5		265	300	7.7
Station Number CAN 043									
65	07	07	24.0	2.4	4.2		342	478	7.6
65	08	02	19.0	1.3	3.2	55.0	401	435	8.0
65	08	04	19.0	1.1	4.0		384	420	8.0
65	08	09	19.0	1.8	3.5	40.4	397	428	8.1
65	08	11	20.0	2.4	4.6		370	412	7.7
Station Number CAN 039 (Station at Hornell N.Y.)									
65	06	22	22.0	18.4	11.1			430	7.2
65	08	09	21.0	10.5	5.6	48.0	370	440	7.9
65	08	11	19.0	21.4	1.9		346	412	7.6
Station Number CAN 036 (Station at Hornell, N.Y.)									
65	06	22	25.5	20.6	10.6			460	5.9
65	07	08	23.0	23.5	0.3	4.1		370	7.5
65	08	02	20.0	18.7	8.6	10.2		310	8.3
65	08	04	20.0	12.6	0.3			469	7.5
65	08	09	24.0	15.8	0.0	25.0		354	7.4
65	08	11	20.0	15.8	1.3			360	7.3

TABLE E-4 (Continued)

Date Yr	Mo	Da	Water Temp. °C.	Stream Flow cfs	D.O. mg/l	BOD_5 mg/l	Net Alk. mg/l (as $CaCO_3$)	Cond. µ-mho cm	pH
Station Number CAN 035 (Station at Canisteo, N.Y.)									
65	07	08	19.0	24.2	0.0	17.3	289		7.5
65	08	03	15.0	16.3	12.9	8.3	355		7.5
65	08	04	16.0	16.1	0.0		516		7.5
65	08	09	22.0	16.3	0.0	25.0	370		7.5
65	08	11	19.0	16.3	0.0		362	470	7.3
Station Number CAN 032 (Station at Canisteo, N.Y.)									
65	06	22	25.5	21.5	3.5			440	5.9
65	07	08	23.0	24.3	0.0	9.6	288	395	7.4
65	08	03	15.0	16.4	0.0	17.2	357	395	9.0
65	08	04	20.0	16.2	0.6		346	479	7.5
65	08	09	24.0	16.4	0.0	21.0	368	513	7.4
65	08	11	20.0	16.4	0.0		369	402	7.5
Station Number CAN 031 (Station downstream from Canisteo, N.Y.)									
65	06	22	22.0	26.5	6.8			370	6.6
65	07	08	23.0	33.1	4.5	11.6	240	370	7.8
65	08	03	17.0	13.1	0.6	24.0	313	388	7.6
65	08	04	21.0	13.1	0.8		305	404	7.6
65	08	09	24.0	23.6	1.0	22.0	362	500	7.4
65	08	11	20.0	12.0	0.0		372	469	7.4
Station Number CAN 027 (Station at Adrian, N.Y.)									
65	06	22	22.0	27.8	10.6			375	6.4
65	07	08	23.0	34.7	6.6	24.3	377	391	7.3
65	08	03	19.0	15.9	4.3	22.0	308	390	7.6
65	08	04	21.0	13.7	6.4		317	385	8.0
65	08	10	25.0	21.8	2.2	29.7	320	462	7.5
65	08	12	22.0	9.9	4.5		339	403	7.4

APPENDIX E

TABLE E-4 (Continued)

Date Yr	Mo	Da	Water Temp. °C.	Stream Flow cfs	D.O. mg/l	BOD_5 mg/l	Net Alk. mg/l (as $CaCO_3$)	Cond. μ-mho/cm	pH
Station Number CAN 024									
65	06	22	29.0	34.5	13.0			370	6.5
65	08	03	19.0	16.9	4.6	22.0	296	380	6.0
65	08	04	21.0	14.5	5.0		308	395	8.1
65	08	10	23.0	26.1	3.8	11.5	309	454	7.6
65	08	12	21.0	13.3	5.0		458	458	7.5
Station Number CAN 021									
65	06	23	22.0	46.0	7.3			389	6.6
65	08	03	20.0	25.0	7.0	19.0	216	310	8.3
65	08	04	22.0	23.1	8.5		305	389	8.4
65	08	10	18.0	17.7	5.6		302	448	7.8
65	08	12	21.0	23.1	6.0			431	8.0
Station Number CAN 017									
65	06	23	23.0	54.6	6.4			380	7.2
65	08	03	20.0	35.0	7.2	25.6	281	345	8.8
65	08	05	24.0	22.9	11.5		245	346	8.9
65	08	10	24.0	18.2		9.1	288	423	8.1
65	08	12	22.0	26.8	6.4		318	417	8.6
Station Number CAN 012									
65	06	23	24.0	55.6	6.6			350	7.2
65	08	03	21.0	32.4	9.4	28.4	255	396	8.9
65	08	05	24.0	25.9	9.9		239	310	9.1
65	08	10	24.0	43.1	7.4	4.0	262	380	8.2
65	08	12	22.0	38.0	11.0			380	8.8
Station Number CAN 000									
65	06	23	25.0	66.9	12.0			300	7.6
65	07	20	16.0	54.8	8.8		162	220	8.7
65	08	03	22.0	27.0	8.3	9.0	82	300	8.7
65	08	05	24.0	35.0	13.0		186	288	8.5
65	08	10	24.0	25.3	8.5	3.7	200	341	7.8

APPENDIX E

TABLE E-4 (Continued)

Date			Water Temp.	Stream Flow	D.O.	BOD_5	Net Alk. mg/l	Cond. μ-mho	
Yr	Mo	Da	°C.	cfs	mg/l	mg/l	(as $CaCO_3$)	cm	pH
Station Number CAN 000 (Continued)									
65	08	12	22.0	23.1	11.0		223	340	8.2
65	08	30	17.0	31.3	7.3	4.2	178	300	8.1
65	08	31	17.0	29.9	7.9		110	304	8.3
65	09	01	19.0	36.2	7.9		179	340	7.9
65	09	20	26.0	47.6	6.0	2.8	202	385	9.0
65	09	24	22.0	33.6	11.0	2.9	212	369	8.3

APPENDIX E

TABLE E-5

1965 WATER QUALITY SAMPLING RESULTS
FWPCA, CB-SRBP

COHOCTON RIVER

Date Yr	Mo	Da	Water Temp. °C.	Stream Flow cfs	D.O. mg/l	BOD_5 mg/l	Net Alk. mg/l (as $CaCO_3$)	Cond. μ-mho/cm	pH
Station Number COH 038									
65	06	16	13.0	13.1	9.7			380	6.0
65	07	06	19.0	7.2	7.8		298	350	7.9
65	07	12	22.0	6.6	7.6		258	295	7.9
65	07	23	23.0	5.4	10.0		242	310	8.3
65	07	27	16.0	4.4	6.8		268	292	8.3
65	07	28	12.0	4.4	9.0		278	280	8.4
65	07	29	16.0	4.2	10.1	4.9	276	290	8.2
Station Number COH 036									
65	07	06	19.0	7.8	4.8		320	327	6.7
65	07	12	20.0	7.2	3.2		256	333	7.3
65	07	23	20.0	6.9	2.9		262	348	7.7
65	07	27	20.0	4.8	2.2		268	335	7.8
65	07	28	18.0	4.8	2.4		280	316	7.8
65	07	29	16.0	4.5	2.4	1.0	277	315	7.9
Station Number COH 034									
65	07	06	19.0	8.1	12.5		250	298	7.2
65	07	12	20.0	7.4	11.6		231	290	8.2
65	07	23	20.0	6.1	14.4		217	348	8.8
65	07	27	20.0	6.0	10.4		247	320	8.3
65	07	28	19.0	6.0	13.4		251	292	8.8
65	07	29	18.0	4.7	14.7	2.8	250	281	9.5
Station Number COH 023									
65	07	12	20.0	45.7	9.8		202	272	8.2
65	07	23	20.0	41.6	11.3			282	
65	07	27	20.0	31.7	8.3		207	280	8.0
65	07	28	20.0	34.1	8.3		242	280	8.3
65	07	29	18.0	34.1	9.6	2.0	238	221	8.7

APPENDIX E

TABLE E-5 (Continued)

Date Yr	Mo	Da	Water Temp. °C.	Stream Flow cfs	D.O. mg/l	BOD_5 mg/l	Net Alk. mg/l (as $CaCO_3$)	Cond. µ-mho cm	pH
Station Number COH 021 (Station at Bath, N.Y.)									
65	07	12	23.0	47.7	13.0		202	300	8.4
65	07	23	20.0	41.4	15.7		204	292	8.7
65	07	27	19.0	39.2	10.7		151	280	8.4
65	07	28	21.0	39.4	14.2		218	290	8.8
65	07	29	13.0	39.4	13.6	18.2	231	250	9.1
Station Number COH 018 (Station at Bath, N.Y.)									
65	06	16	20.0	69.4	14.0			320	7.6
65	07	12	23.0	48.7	13.5		212	300	8.5
65	07	23	20.0	42.6	16.0		209	310	8.7
65	07	27	19.0	39.9	11.4		207	280	8.1
65	07	28	20.0	40.1	11.7		228	290	8.5
65	07	29	13.0	40.1	13.6	3.0	355	232	9.6
Station Number COH 009									
65	06	17	15.0	83.8	11.5			340	7.7
65	07	06	22.0	64.5	12.5		229	300	8.1
65	07	13	23.0	64.5	8.0		195	285	8.3
65	07	26	23.0	52.3	6.4	3.6	370	318	8.1
65	07	27	23.0	48.9	9.3		176	311	8.3
65	07	28	20.0	48.9	9.5		192	300	8.5
65	07	29	8.0	50.6	9.9		198	250	9.4
Station Number COH 007									
65	07	13	22.0	64.9	7.2		173	295	8.2
65	07	26	23.0	52.6	6.4	3.4	336	335	8.0
65	07	27	24.0	49.2	6.4		187	328	7.6
65	07	28	22.0	49.2	5.9		191	302	8.4
65	07	29	20.0	50.9	6.2		196	310	7.8

APPENDIX E

TABLE E-5 (Continued)

Date Yr	Mo	Da	Water Temp. °C.	Stream Flow cfs	D.O. mg/l	BOD_5 mg/l	Net Alk. mg/l (as $CaCO_3$)	Cond. µ-mho/cm	pH
Station Number COH 006									
65	06	17	16.0	84.0	0.0			340	7.4
65	07	06	23.0	65.2	12.1		294	316	6.0
65	07	13	25.0	65.0	12.3		183	287	8.8
65	07	26	23.0	52.8	9.5	3.5	368	339	8.3
65	07	27	24.0	49.4	10.9		189	330	8.5
65	07	28	22.0	49.3	10.4		187	312	7.5
65	07	29	20.0	51.0	8.8		205	315	8.3
Station Number COH 004									
65	07	26	24.5	52.8	8.8	7.0	184	310	8.1
65	07	27	20.0	49.4	9.0		195	325	8.3
65	07	28	21.0	49.3	9.9		187	300	8.0
65	07	29	18.5	51.0	9.3		193	312	8.2
Station Number COH 001									
65	06	17	15.5	87.4	12.1			320	7.8
65	07	20	18.0	71.1	10.2		186	270	8.3
65	07	26	24.0	54.0	10.5	3.9	207	322	8.6
65	07	27	21.0	50.6	10.2		205	322	8.5
65	07	28	20.0	50.4	10.1		205	310	8.3
65	07	29	18.0	52.1	9.8		216	319	8.3
65	08	30	17.0	29.5	10.0	3.5	176	304	5.8
65	08	31	18.0	27.5	10.4		171	310	9.1
65	09	20	27.0	25.4	12.4		182	382	8.8
65	09	24	22.0	27.1	7.4		187	403	8.1

APPENDIX E

TABLE E-6

1965 WATER QUALITY SAMPLING RESULTS
FWPCA, CB-SRBP

CHEMUNG RIVER

Date Yr	Mo	Da	Water Temp. °C.	Stream Flow cfs	D.O. mg/l	BOD_5 mg/l	Total Hard. mg/l	Chl. mg/l	Net Alk. mg/l (as $CaCO_3$)	Cond. µ-mho cm	pH	Total Iron mg/l	Mang. mg/l	Sulfate mg/l
Station Number CHM 044 (Station at Corning, N.Y.)														
65	07	01	25.0	163.0	9.5				84	330	8.1			
65	07	20	19.0	136.5	9.9				149	358	8.6			
65	08	30	18.0	135.2	7.7	14.0	153	25	124	320	8.0	1.5		76
65	08	31	17.0	143.0	8.1		149		80	315	7.8	1.5		71
65	09	01	21.0	131.0	6.0			29	121	339	7.3	1.8		
65	09	20	27.0	131.0	11.7	3.0			156	417	8.4			
65	09	24	22.0	115.3	6.2	29.5			147	410	7.6			
65	10	01	20.0	107.2	7.6	20.9			142	301	8.4			
65	10	04	15.0	155.0	10.6				144	275	8.4			
65	10	11		143.0	9.6	4.2			125	385	8.1			
65	11	02	20.0	135.2	11.6	5.5	179		116	360	8.5	0.0	0.2	51
65	11	04	20.0	147.0	10.9	14.8	207		130	440	7.9	0.0	0.2	88
65	11	10	20.0	159.6	12.2	9.6	152		94	400	8.5	0.3	0.2	106
Station Number CHM 043 (Station at Corning, N.Y.)														
65	10	04	15.0	137.5	11.4	100.0			201	451	9.2			
Station Number CHM 042 (Station at Corning, N.Y.)														
65	07	01	25.0	163.1	11.7				44	320	7.2			
65	07	20	20.0	142.8	10.7				151	283	8.9			
65	10	01	21.0	118.4	11.0				143	373	8.5			
65	10	04	16.0	138.7	12.0				187	386	8.0			
65	10	11	18.0	146.9	12.8	3.2			122	339	8.1			
65	11	02	25.0	138.7	11.3	10.3	184		119	370	8.3	0.0	0.2	44
65	11	04	20.0	159.0	11.1	14.9	178		60.3	425	7.5	0.0	0.2	81
65	11	10	20.0	248.6	12.4	11.2	146		115.1	405	6.5	0.0	0.2	66

APPENDIX E

TABLE E-6 (Continued)

Date			Water Temp.	Stream Flow	D.O.	BOD_5	Total Hard.	Chl.	Net Alk. mg/l (as $CaCO_3$)	Cond. µ-mho		Total Iron	Mang.	Sulfate
Yr	Mo	Da	°C.	cfs	mg/l	mg/l	mg/l	mg/l		cm	pH	mg/l	mg/l	mg/l
Station Number CHM 041														
65	10	04	15.0	139.1	2.8	3.5			424	753	7.6			
Station Number CHM 040														
65	07	22	24.0	127.3	8.2				112	330	8.3			
65	10	04	15.0	139.7	9.2				187	386	8.0			
Station Number CHM 039														
65	07	22	24.0	127.9	6.6				104	308	7.5			
Station Number CHM 036														
65	07	01	25.0	182.7	10.8				84	320	7.6			
65	07	21	25.0	145.4	7.2	2.9			156	210	8.3			
65	10	01	22.0	120.6	9.4				150	408	8.5			
65	10	11	16.0	162.0	11.6	3.4			140	371	8.2			
65	11	02	20.0	153.7	11.6	9.4	181		116	360	8.1	0.0	0.2	51
65	11	04	20.0	157.8	11.3	8.4	180		112	420	8.2	0.0	0.2	88
65	11	10	20.0	283.1	11.5	12.8	160		122	390	8.3	0.4	0.2	73
Station Number CHM 030 (Station at Elmira, N.Y.)														
65	07	01	25.0	176.4	8.0				80	320	7.6			
65	07	21	5.0	148.2	9.1	1.7			154	230	8.6			
65	10	01	22.0	144.8	11.8				159	401	9.0			
65	10	11	18.0	176.4	12.4	2.8			147	369	8.8			
65	11	02	20.0	156.8	11.3	7.4	168		119	365	8.2	0.1	0.2	
65	11	04	20.0	156.8	11.6	4.6	166		60.3	420	7.3	0.0	0.2	62
65	11	10	20.0	299.0	12.6	27.2	162		119	385	8.0	0.1	0.2	81
Station Number CHM 026 (Station at Elmira, N.Y.)														
65	07	01	25.0	175.2	10.6				69	310	7.7			
65	07	21	5.0	145.4	9.3	1.7			167	225	9.0			
65	10	01	22.0	153.8	12.0	22.0			157	400	9.3			
65	10	11	19.0	220.3	11.4	3.2			147	371	8.7			
65	11	02	20.0	141.0	13.8	3.3	177		116	340	8.4	0.1	0.2	103

APPENDIX E

TABLE E-6 (Continued)

Date Yr	Mo	Da	Water Temp. °C.	Stream Flow cfs	D.O. mg/l	BOD_5 mg/l	Total Hard. mg/l	Chl. mg/l	Net Alk. mg/l (as $CaCO_3$)	Cond. µ-mho cm	pH	Total Iron mg/l	Mang. mg/l	Sulfate mg/l
Station Number CHM 026 (Continued)														
65	11	04	20.0	141.0	13.8	10.0	241		122	410	8.6	0.0	0.2	81
65	11	10	20.0	240.0	14.4	33.0	274		125	395	8.3	0.1	0.2	55
Station Number CHM 019														
65	06	29	27.0	231.2	8.9					390	6.0			
65	07	21	5.0	180.8	8.8				189	309	8.4			
65	09	28	20.0	141.7	10.0	2.0			175	418	8.3			
65	10	08	16.0	200.4	9.0	18.0			177	468	8.2			
65	10	15	19.0	166.2	9.8	19.6			177	477	8.3			
65	11	02	20.0	171.1	8.7	8.0	177		130	420	8.1	0.0	0.2	51
65	11	04	20.0	180.8	8.5	8.2	180		94	460	7.2	0.0	0.2	81
65	11	10	20.0	210.2	6.7	20.4	180		229	400	6.5	0.2	0.2	88
Station Number CHM 012														
65	06	29	22.0	236.5	10.6					390	6.0			
65	07	22	24.0	175.0	9.0				102	318	8.8			
65	09	29	19.0	170.0	10.2	5.3			174	392	8.6			
65	10	08	16.0	258.5	12.4	12.5			182	408	8.7			
65	10	15	17.0	170.0	11.6	20.8			175	414	8.6			
65	10	28	8.0	236.5	8.3					500	7.8			
65	11	02	25.0	185.0	11.5	9.5	188		145	430	8.4	0.0	0.4	40
65	11	04	25.0	185.0	11.6	8.5	180		125	440	7.8	0.0	0.4	88
65	11	10	25.0	205.0	4.8	18.0	160		88	410	7.5	0.1	0.4	59
Station Number CHM 005														
65	06	29	26.0	268.3	8.0					390	6.5			
65	07	22	24.0	172.8	9.9				132		6.8			
65	09	07	17.5	182.9	8.2		110		118	405	7.1	0.1		93
65	09	08	19.0	172.8	8.3		302		114	395	7.5	0.0	0.08	68
65	09	09	19.0	152.4	7.4	1.1	123		115	385	8.1	0.1	0.02	
65	09	28	18.0	142.3	11.6				181	350	9.1			
65	10	08	16.0	167.7	13.0	15.2			189	399	9.0			
65	10	15	17.0	182.9	13.4	21.6			174	401	8.8			
65	11	02	25.0	177.8	13.2	7.1	175		142	425	8.2	0.0	0.4	55

APPENDIX E

TABLE E-6 (Continued)

Date			Water Temp.	Stream Flow	D.O.	BOD_5	Total Hard.	Chl.	Net Alk. mg/l (as $CaCO_3$)	Cond. μ-mho	pH	Total Iron	Mang.	Sulfate
Yr	Mo	Da	°C.	cfs	mg/l	mg/l	mg/l	mg/l		cm		mg/l	mg/l	mg/l
Station Number CHM 005 (Continued)														
65	11	04	25.0	172.8	13.2	8.5	198		133	490	8.4	0.0	0.4	88
65	11	10	25.0	188.0	14.2	12.0	180		140	520	8.3	0.1	0.4	59
Station Number CHM 003														
65	06	29	25.0	263.5	7.9					390	6.8			
65	07	22	19.0	173.3	8.4				251	350	8.8	0.0	0.06	
65	09	07	18.0	188.6	7.5		142		95	385	7.3	0.0	0.11	
65	09	08	19.0	173.3	7.7	6.0	342		115	410	7.5	0.0	0.11	
65	09	09	19.0	152.9	6.5	1.1	114			380	8.2	0.1	0.11	

APPENDIX E

TABLE E-7

1968 WATER QUALITY SAMPLING RESULTS

CHEMUNG RIVER

Date Yr	Mo	Da	Water Temp. °C.	D.O. mg/l	BOD_5 mg/l	Net Alk. mg/l (as $CaCO_3$)	pH	NH_3-N	Org-N	Total PO_4	Coliform MF/100 ml	% Sat. D.O.	Nitrate N (mg/l)	Chl. mg/l
Station Number CHM 044 (Left Bank)														
68	06	26	17	7.8	5	73	7.4	0.8	1.0	1.8	29,000	80.1		
68	07	09	24	9.4	2	---	7.9	0.4	0.8	0.65	16,800	110		
68	07	17	28	7.0	1.2	86	8.0	0.06	0.4	0.95	34,000	88.4		
68	07	24	25	5.6	2.0	90	8.0	0.06	0.7	0.90	---	66.8		
68	07	31	23	6.8	1.6	105	8.3	0.06	0.7	4.6	7,800	78.3		
68	08	07	27	6.6	0.8	73	8.0	0.06	0.6	1.2	6,700	81.8		
68	08	14	23	6.1	1.2	84	8.1	0.04	0.7	1.2	---	76.0		
68	08	21	24	7.0	1.2	100	8.3	0.04	1.0	1.6	38,000	82.1	4.0	
(Right Bank)														
68	06	26	17	8.2	2	40	7.3	0.04	0.1	0.75	8,000	84		
68	07	09	24	9.2	2	69	7.6	0.04	0.8	0.62	6,600	108		
68	07	17	28	6.6	1.4	85	7.9	0.06	0.6	1.0	4,300	83.3		
68	07	24	25	5.0	1.8	88	7.9	0.06	0.7	0.85	---	59.7		
68	07	31	23	6.6	1.8	104	8.5	0.06	0.8	3.0	---	76		
68	08	07	27	6.4	1.8	---	7.9	0.06	0.7	1.3	3,300	79.3		66
68	08	14	22	6.8	0.8	73	8.0	0.02	0.6	0.9	---	77		
68	08	21	24	6.8	1.2	96	8.1	0.02	1.0	0.85	19,000	79.7		
Station Number CHM 042 (Left Bank)														
68	06	26	17	7.6	3	59	7.4	0.08	0.7	2.0	31,000	78.0		
68	07	09	24	8.6	2	72	8.3	0.04	0.5	0.52	3,500	105		
68	07	17	28	6.6	1	92	8.3	0.06	1.0	0.90	3,100	83.3		
68	07	24	26	6.0	2.2	90	8.3	0.04	0.63	1.3	---	73		
68	07	31	23	8.6	1.4	101	8.4	0.04	0.6	3.0	2,600	99.1		
68	08	07	27	6.6	1.4	100	8.3	0.008	0.6	1.4	4,500	81.8		
68	08	14	23	9.4	1.0	87	8.2	0.04	0.6	1.0	---	108		
68	08	21	25	9.0	1.0	104	8.6	0.06	1.0	1.2	400	107		

APPENDIX E

TABLE E-7 (Continued)

Date			Water Temp.	D.O.	BOD_5	Net Alk. mg/l				Total	Coliform	% Sat.	Nitrate	Chl.
Yr	Mo	Da	°C.	mg/l	mg/l	(as $CaCO_3$)	pH	NH_3-N	Org-N	PO_4	MF/100 ml	D.O.	N (mg/l)	mg/l
Station Number CHM 042 (Continued) (Right Bank)														
68	06	26	17	8.0	3	46	7.2	0.08	0.8	0.70	29,000	82		
68	07	09	24	9.2	2	82	8.3	0.04	0.7	0.50	5,400	108		
68	07	17	28	6.6	1.8	91	8.3	0.06	1.0	1.2	3,000	83.3		
68	07	24	26	5.6	2.4	91	8.3	0.06	0.7	0.92		68.1		
68	07	31	23	7.6	1.4	100	8.5	0.04	0.9	6.6	2,500	87.6		
68	08	07	27	6.6	1.4	89	8.3	0.04	0.7	0.8	3,100	81.8		
68	08	14	21	8.0	0.8	84	8.2	0.04	0.8	1.2		89.0		
68	08	21	25	9.0	0.8	96	8.4	0.06	0.8	1.2	28,000	107		
Station Number CHM 041 (Center Stream)														
68	07	17	28	7.6	1	93	8.5	0.06	0.6	0.95	4,700	92.2	2.0	16
68	07	24	26	7.0	1.8	95	8.5	0.06	0.39	0.85	3,900	85.2	---	
68	07	31	23	8.0	1.2	104	8.5	0.04	0.7	3.0	6,000	92.2	---	21
68	08	07	27	6.8	1.4	92	8.3	0.06	0.04	1.2	220,000	84.3	---	22
68	08	14	23	8.8	1.2	86	8.2	0.04	0.8	1.2	33,000	101	---	20
68	08	21	26	7.6	1.0	106	8.4	0.04	1.0	1.4	800,000	92.5	4.8	24
Station Number CHM 037 (Left Bank)														
68	06	26	17	8	3	44	7.1	0.08	0.1	0.98	59,000	82.1		
68	07	03	25	8		50	7.4		0.7	0.40	3,000	95.5		
68	07	09	26	11.2	3	80	8.6	0.04	0.8	2.1	12,700	136		
68	07	17	28	8.0	1.2	95	8.4	0.06	0.7	1.1	5,600	101		
68	07	24	27	7.0	2.2	97	8.4	0.06	0.5	1.3	6,500	86.7		
68	07	31	26	7.8	1.2	102	8.5	0.04	1.0	5.0	6,300	94.9		
68	08	07	28	6.8	1.0	102	8.3	0.06	0.7	1.4	170,000	85.9		
68	08	14	25	8.6	1.0	98	8.3	0.04	0.9	2.0	18,000	103		
68	08	21	29	9.2	1.0	98	8.5	0.04	0.9	1.6	36,000	118		

APPENDIX E

TABLE E-7 (Continued)

Date Yr	Mo	Da	Water Temp. °C.	D.O. mg/l	BOD_5 mg/l	Net Alk. mg/l (as $CaCO_3$)	pH	NH_3-N	Org-N	Total PO_4	Coliform MF/100 ml	% Sat. D.O.	Nitrate N (mg/l)	Chl. mg/l
Station Number CHM 037 (Continued) (Right Bank)														
68	06	26	17		3	41	7.2	0.08	0.7	0.92	18,000			
68	07	03	25	7.6	1	42	7.2		0.7	0.32	14,000	90.7		
68	07	09	26	12.2	2	82	8.4	0.04	0.6	0.55	14,400	148		
68	07	17	28	8.2	1	93	8.4	0.04	0.7	1.4	5,600	104		
68	07	24	27	5.6	1.6	95	8.3	0.06	0.5	1.1	2,100	69.4		
68	07	31	26	9.8	2.0	108	8.5	0.04	0.9	2.9	9,360	119		
68	08	07	28	6.8	0.8	98	8.4	0.04	1		30,000	85.9		
68	08	14	25	7.6	1.4	96	8.3	0.02	0.9	1.2	8,100	90.7		
68	08	21	28	9.0	1.0	100	8.6	0.02	1.1	1.4	12,000	114		
Station Number CHM 030 (Left Bank)														
68	06	26	24	7.6	2	44	7.2	0.06	0.8	1.0	44,000	89.1	0.16	4
68	07	09	26	11.4	3	83	8.5	0.08	0.8	0.62	62,000	139	0.6	14
68	07	17	30	8.0	0.8	92	8.4	0.06	0.8	1.2	300	105	0.16	17
68	07	24	27	6.2	1.2	95	8.3	0.04	0.4	10.85	6,700	76.8	10.0	20
68	07	31	26	8.0	1.2	106	8.6	0.04	0.74	4.9	28,000	97.3	3.6	19
68	08	07	27	7.8	2.4	100	8.4	0.06	1	0.75	3,800	96.7	0.3	22
68	08	14	24	8.8							66,000	103		
68	08	21	27	8.4	1.0	104	8.6	0.04	0.7	2.0	55,000	104	4.0	23
(Right Bank)														
68	06	26			1	45	7.5		1.3	0.5	1,000		0.8	8
68	07	09	26	12.8	3	80	8.5	0.08	0.8	0.55	300	156	0.6	11
68	07	17	30	8.2	1.2	91	8.3	0.04	0.7	1.0	6,700	108	2.0	18
68	07	24	27	6.4	1.4	96	8.3	0.06	0.5	1.1	26,000	79.3	10.0	21
68	07	31	26	8.2	1.4	107	8.5	0.04	1.0	5.9	6,800	99.8	0.1	20
68	08	07	28	7.2	1.2	100	8.3	0.06	0.6	3.0	5,500	90.9	0.3	23
68	08	14	25	8.2							37,000	97.9		
68	08	21	27	9.0	1.0	105	8.6	0.04	1.2	1.2	3,300	112	1.6	22

APPENDIX E

TABLE E-7 (Continued)

Date			Water Temp.	D.O.	BOD_5	Net Alk. mg/l				Total	Coliform	% Sat.	Nitrate	Chl.
Yr	Mo	Da	°C.	mg/l	mg/l	(as $CaCO_3$)	pH	NH_3-N	Org-N	PO_4	MF/100 ml	D.O.	N (mg/l)	mg/l
Station Number CHM 026 (Left Bank)														
68	06	26		8.4	2	41	7.4	0.08	0.6	0.92	59,000		24	16
68	07	09	26	11.4	3	81	9.0	0.06	0.8	0.7	400	139		
68	07	17	30	7.4	1.8	93	8.4	0.04	0.7	1.7	3,000	97		
68	07	24	28	6.2	1.0	99	8.5	0.04	0.5	0.85	11,000	78.3		
68	07	31	26	8.8	1.0	105	8.6	0.04	0.74	5.2	8,400	107		
68	08	07	28	8.2		103	8.5	0.02	0.7	1.2	26,000	104		
68	08	14	26	11	1.0	101		0.02	0.8	1.6	3,100	134		
68	08	21	28	10.4	1.2	106	8.5	0.04	0.9	1.2	6,300	131		
(Right Bank)														
68	06	26			1	49	7.6	0.08	0.7	1.2	29,000		24	10
68	07	09	26	11.2	3	79	9.2	0.04	0.8	0.38	300	136		
68	07	17	30	8.2	1	92	8.5	0.06	0.6	1.0	350	108		
68	07	24	28	7.6	1.4	98	8.5	0.04	0.5	1.2	4,800	96		
68	07	31	26	9.6	1.4	106	8.5	0.04	0.7	2.6	1,100	117		
68	08	07	28	8.2	1.6	101	8.4	0.02	0.7	1.8	6,800	104		
68	08	14	24	10.0	1.0	98	8.5	0.04	0.7	1.3	1,100	117		
68	08	21	28	11.2	1.0	107	8.6	0.02	1	0.8	2,700	141		
Station Number CHM 025 (Left Bank)														
68	07	02	26	7.6	1	67	7.6	0.04	0.6	0.68	15,000	92.5		
68	07	10	25	9.4	3	84	8.6	0.06	0.7	0.8	66,000	112		
68	07	18	28	4.8	3.6	126	7.9	0.08	1.0	2.2	120,000	60.6		
68	07	25	26	6.2	2.0	134	7.7	0.06	1.1	0.66	260,000	75.4		
68	08	01	23	6.4	3.0	140	7.9	0.06	1.0	5.6		73.7		
68	08	08	28	6.4	3.0			0.06	0.8	1.6	500,000	80.8		
68	08	15	22	4.0	4.8	132		0.06	0.7	1.7	547,000	46.3		
68	09	10	26	3.0	2.0	107	8.3	0.04	1.4	1.4		36.5		

APPENDIX E

TABLE E-7 (Continued)

Date			Water Temp.	D.O.	BOD_5	Net Alk. mg/l				Total	Coliform	% Sat.	Nitrate	Chl.
Yr	Mo	Da	°C.	mg/l	mg/l	(as $CaCO_3$)	pH	NH_3-N	Org-N	PO_4	MF/100 ml	D.O.	N (mg/l)	mg/l
Station Number CHM 025 (Continued) (Right Bank)														
68	07	02	26	8.4	1	52	7.5	0.04	0.5	0.4	3,000	102		
68	07	10	25	8.0	2	88	8.5	0.04	0.5	0.55	1,400	96		
68	07	18	28	6.0	1.6	99	8.3	0.04	0.7	2.8	51,000	75.8		
68	07	25	26	7.0	1.6	98	8.1	0.04	1.0	1.8	510,000	85.2		
68	08	01	23	6.2	1.4	107	8.3	0.04	0.9	3.9		71.4		
68	08	08	28	7.0	1.6			0.06	0.61	0.6	9,100	88.4		
68	08	15	23	8.4	1.4	106		0.02	0.6	0.8	3,700	96.8		
68	08	22	26	7.4	3.4	105	8.5	0.02	1.1	0.7		90		
Station Number CHM 024 (Left Bank)														
68	07	02	26	7.2	1	60	7.5	0.04	0.6	0.6	14,000	87.6	24	9
68	07	10	24	9	2	80	8.6	0.006	0.8	0.8	29,000	106	0.6	17
68	07	18	28	5.2	1.4	100	8.0	0.06	1.2	1.6	63,000	65.7	0.8	21
68	07	25	26	6.2	1.2	97	8.0	0.04	1.0	1.7	44,000	75.4	1.6	25
68	08	01	23	6.2	1.4	121	8.2	0.04	1.0	5.4		71.4	0.2	26
68	08	08	28	5.6	1.8			0.04	0.7	1.2	180,000	70.7	0.3	27
68	08	15	22	6.4	1.8	114		0.02	0.6	0.9	188,000	72.5	3.2	35
68	08	22	25	5.8	1.2	127	8.3	0.04	1.1	1.4	31,000	69.2		32
(Right Bank)														
68	07	02	26	6.8	1	56	7.4	0.04	0.8	0.85	1,000	82.7	2.0	
68	07	10	24	8.6	4	89	8.4	0.08	1.5	1.6	1,400	101	0.36	18
68	07	18	28	4.8	1.6	98	8.1	0.06	1.2	3.0	2,100	60.6	0.8	21
68	07	25	26	6.0	1.4	102	7.9	0.06	0.8	1.6	42,000	73.0	1.6	25
68	08	01	23	5.8	3.6	106	7.8	0.04	1.9	4.8		66.8	0.2	29
68	08	08	28	5.0	1.8			0.04	1.4	1.4	800,000	63.1	7.0	24
68	08	15	22	6.0	5.6	117		0.06	2.3	2.4	4,800	68	1.0	32
68	08	22	25	4.4	2.0	129	8.1	0.08	2.6	3.4	6,900	52.5	1.8	34

APPENDIX E

TABLE E-7 (Continued)

Date			Water Temp.	D.O.	BOD_5	Net Alk. mg/l				Total	Coliform	% Sat.	Nitrate	Chl.
Yr	Mo	Da	°C.	mg/l	mg/l	(as $CaCO_3$)	pH	NH_3-N	Org-N	PO_4	MF/100 ml	D.O.	N (mg/l)	mg/l
Station Number CHM 021 (Left Bank)														
68	07	02	25	7.2	1	57	7.5	0.04	0.6	1.4	11,000	85.9		
68	07	10	25	8.8	3	88	8.6	0.06	0.8	0.6	29,000	105		
68	07	18	28	5.0	1.8	94	7.9	0.08	0.9	1.1	64,000	63.1		
68	07	25	26	4.8	1.0	102	7.9	0.04	0.7	2.9	27,000	58.4		
68	08	01	23	5.8	2.2	124	7.9	0.04	1.1	5.9		66.8		
68	08	08	27	5.8	1.8			0.04	0.9	1.4	350,000	71.9		
68	08	15	22	5.4	2.2	119	7.9	0.06	1.2	1.6	88,000	61.2		
68	08	22	27	3.4	6.8	124	8.0	0.06	1.5	2.5	45,000	42.1		
(Right Bank)														
68	07	02	25	7.2	1	62	7.3	0.04	0.6	0.62	5,000	85.9		
68	07	10	25	8.0	3	89	8.3	0.04	0.9	0.52	29,000	96		
68	07	18	28	5.4	2	94	7.9	0.06	1.0	1.2		68.2		
68	07	25	26	5.0	1.2	102	7.9	0.08	0.9	2.3	44,000	60.8		
68	08	01	23	5.8	2.2	119	8.0	0.06	1.0	6.3		66.8		
68	08	08	27	6.0	1.8			0.04	0.9	2.0	540,000	74.3		
68	08	15	23	4.0	2.4	115	7.9	0.06	1.2	1.4	111,000	46.1		
68	08	22	27	4.0	2.4	129	8.1	0.06	1.5	2.2	17,000	49.6		
Station Number CHM 019 (Left Bank)														
68	07	02	25	6.8	2	46	7.1	0.04	1.0	0.62	10,000	81.1	1.2	10
68	07	10	25	9.0	3	87	8.4	0.06	1.2	0.8	23,000	107	0.32	18
68	07	18	28	4.8	1	87	8.0	0.06	1.6	2.5	71,000	60.6	0.88	16
68	07	25	27	5.6	1.4	91	8.0	0.04	1.1	5.3	39,000	69.4	1.0	26
68	08	01	24	6.2	2.0	120	8.0	0.04	1.0	5.8		72.7	0.2	26
68	08	08	28	6.2	1.6			0.04	0.9	1.6	87,000	78.3	1.2	27
68	08	15	24	6.4	1.4	118	8.1	0.02	1.1	1.6	106,000	75	0.3	33
68	08	22	26	7.0	2.6	133		0.06	1.4	2.1	5,700	85.2	1.6	31

APPENDIX E

TABLE E-7 (Continued)

Date Yr	Mo	Da	Water Temp. °C.	D.O. mg/l	BOD_5 mg/l	Net Alk. mg/l (as $CaCO_3$)	pH	NH_3-N	Org-N	Total PO_4	Coliform MF/100 ml	% Sat. D.O.	Nitrate N (mg/l)	Chl. mg/l
Station Number CHM 019 (Continued) (Right Bank)														
68	07	02	25	7.0	3	59	7.6	0.04	1.2	0.85	10,000	83.5	0.6	10
68	07	10	25	8.2	2	83	8.5	0.06	0.8	0.75	30,000	98	0.04	18
68	07	18	28	5.2	1.8	82	8.0	0.08	0.8	1.8	66,000	65.7	0.8	20
68	07	25	27	4.6	1.4	105	8.0	0.04	1.1	1.6	49,000	57.0	0.8	27
68	08	01	24	6.6	1.8	117	8.1	0.04	1.1	5.4		77.4	0.24	26
68	08	08	28	6.2	2.0			0.04	0.74	1.2	111,000	78.3	7.0	28
68	08	15	24	5.6	1.6	127	8.1	0.06	1	2.0	49,000	65.7	0.4	32
68	08	22	27	6.6	1.4	125	8.3	0.06	1.4	2.1	5,700	81.8	0.8	32
Station Number CHM 016 (Left Bank)														
68	07	02	25	6.6	1	52	7.0	0.04	0.8	0.7	13,000	78.8		
68	07	10	24	8.8	3	86	8.5	0.04	0.9	0.85	8,600	103		
68	07	18	28	5.2	1.8	78	7.8	0.06	1.0	2.5	74,000	65.7		
68	07	25	27	7.2	1.0	100	8.0	0.04	0.8	2.6	43,000	89.2		
68	08	01	23	6.6	2.0	115	8.0	0.04	1.0	4.6		76.0		
68	08	08	28	7.2	2.0			0.04	0.74	1.6	71,000	90.9		
68	08	15	25	6.6	1.4	114	7.9	0.04	0.9	1.4	73,000	78.8		
68	08	22	27	7.6	2.4	123	8.1	0.04	1.3	2.2	2,300	94.2		
(Right Bank)														
68	07	02			5	54	7.4	0.04	0.8	0.7	20,000			
68	07	10	24	9.4	3	88	8.6	0.04	0.9	0.8	11,700	110		
68	07	18	28	5.6	1.6	78	7.8	0.04	0.9	2.4	92,000	70.7		
68	07	25	27	6.2	2.0	98	7.8	0.06	1.1	2.5	35,000	76.8		
68	08	01	23	7.6	1.8	114	8.0	0.04	1.1	5.1		87.6		
68	08	08	28	6.4	1.6			0.04	0.9	0.9	79,000			
68	08	15	24	6.8	1.4	117	7.9	0.04	0.9	1.4	5,400	79.7		
68	08	22	27	6.6	1.2	124	8.1	0.06	1	1.6	400	81.8		

TABLE E-7 (Continued)

Date Yr	Mo	Da	Water Temp. °C.	D.O. mg/l	BOD_5 mg/l	Net Alk. mg/l (as $CaCO_3$)	pH	NH_3-N	Org-N	Total PO_4	Coliform MF/100 ml	% Sat. D.O.	Nitrate N (mg/l)	Chl. mg/l
Station Number CHM 012 (Left Bank)														
68	07	10	24	9.0	3	83	8.6	0.06	1.5	2.0	3,700	106	0.32	18
68	07	18	28	7.0	1.4	102	8.3	0.06	0.5	2.0	7,500	88.4	1.0	25
68	07	25	27	7.4	1.2	98	7.8	0.06	1.4	2.6		91.7	1.0	26
68	08	01	23	8.4	1.0	114	8.1	0.06	0.8	4.8		96.8	0.2	27
68	08	08	28	6.4	1.8			0.04	0.9	1.2	4,900	80.8	0.16	31
68	08	22	28	7.8	1.4	125	8.3	0.04	1.9	1.7	600	98.5	2.4	30
(Right Bank)														
68	07	10	24	9.8	3	88	8.6	0.06	0.1	1.6	2,700	115	0.08	18
68	07	18	28	7.4	1.4	95	8.3	0.06	0.7	1.9	10,500	93.4	1.0	20
68	07	25	27	9.0	2.0	108	8.1	0.06	1.0	3.8	4,900	112	0.4	27
68	08	01	23	7.4	1.4	120	8.2	0.04	0.7	4.2		85.3	0.24	27
68	08	08	28	6.2	2.2			0.06	1.0	1.3	5,100	78.3	0.24	31
68	08	15	25	7.6	1.8	117	7.9	0.06	1	1	10,500	90.7	0.4	29